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Simulation-based interactive multimedia to improve vocational students' learning outcomes

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Abstract

Learning media supporting practical learning in vocational high school (VHS) is urgent during the COVID-19 pandemic. All VHS competencies, including land surveying techniques, cannot support students with the existing online learning facilities. This study explained the development and impact of using multimedia simulation on the learning outcomes of VHS students. The Alessi and Trollip development model with planning, design, and development phases were used to create the multimedia simulation. The participants in this research included teachers, students, material experts, and media experts. The pre-test and post-test of practical learning outcomes, as well as questionnaires, are selected to collect research data. The results based on the experts' and teachers' validation, and students' assessment indicated that the multimedia simulation was 'feasible' to be used in practical learning. Based on students' post-test results, the average score in the experimental class increased more than the average score in the control class. These findings suggested that learning land surveying techniques using multimedia simulation is more effective than classes without using multimedia simulation. Teachers and educational researchers might use this study as an example for creating learning materials to raise the standard of instruction in VHSs.

Keywords: multimedia, simulation, learning outcomes, practical learning, vocational;

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1. Introduction

The primary mission of a vocational high school (VHS) is to prepare middle-level workers for employment in the industry. Most developed countries believe that vocational education plays an essential role in reducing youth unemployment (Dick et al., 2021; Refrigeri & Aleandri, 2013). When the economic standing of certain people is poor, many young people need immediate work, so the presence of vocational education becomes an important social mobility for young people from underprivileged families (Cholik et al., 2021; Owais et al., 2020). Qualified vocational students become a bridge between the quality of human resources and industry (Alberts & Stevenson, 2017; Lund & Karlsen, 2020; Wibawanto et al., 2021). Therefore, both curriculum and learning processes must be continuously updated to better meet the requirements of industry demands.

Interaction between students and their learning environment is essential in vocational schools (Budi et al., 2021; Nahriana & Arfandi, 2020), especially to provide understanding and experience of the content of the material through training activities so that learning objectives are optimally attained (Hadaya & Hanif, 2019; Pamungkas et al., 2020; Prianto et al., 2020). Additionally, learning media for VHS students is a crucial component that raises students' motivation for learning and helps them become more accustomed to the workforce (Huwaidi et al., 2021; Nugraha & Wahyono, 2019). Creatively, designed learning to attract students' interest improves students' knowledge and skills in learning technology innovations (Liu et al., 2011). Innovation and technology implementation are key factors in improving learning at the cognitive, affective, and psychomotor levels that are relevant to VHS students.

Vocational education must innovate swiftly due to the quick growth of educational technology and the challenges of online learning. Vocational schools should ideally have industry-appropriate facilities and infrastructure. During the pandemic, schools face challenges in providing these facilities and infrastructure because students cannot attend laboratories, workshops, or find practical learning equipment based on their own abilities (Bima et al., 2021; Tawafak et al., 2021).

Online learning has been implemented since the beginning of the 2020 pandemic until now, encouraging the potential for the development of technological innovation in education (Cho et al., 2021; Churi et al., 2022). Furthermore, the practice of distant learning is facilitated by technological innovation in the form of instructional digital learning media. (Wibawanto & Roemintoyo, 2020; Widyaningsih et al., 2020). Students find it difficult to use video conferencing every day. Another negative impact on learning that requires laboratory space is that it is difficult to do. Learning technologies, such as augmented reality or virtual laboratories for certain subjects, need to be developed so that students continue to get the expected competencies. These negative impacts need to be addressed and strived to improve learning since the COVID-19 pandemic has no known end date. This intervention or solution can also be considered for the innovation of post-COVID-19 learning technology.

In truth, Indonesian vocational education is not exempt from this issue. Distance learning in VHSs is affected negatively by learning during the pandemic. Online learning activities since the COVID-19 pandemic were discussed in the initial observations utilizing a questionnaire on January 10–13, 2021. The questionnaires were distributed to students of the Construction and Property Engineering Skills Programme Vocational Schools in the city of Surakarta. The questionnaire questions are devoted to the subjects of building construction fundamentals and land measurement techniques. The selection of these subjects is based on the difficulty of implementing online practicum learning. Then, the respondents consisted of students in grades X and XI, Competency of Building Modelling and

Information Design Skills and Construction and Property Business Expertise Competencies. Table 1 displays the questionnaire's findings.

Table 1. Results of online learning activity questionnaire

No	Indicator	Response	Percentage
1.	Practical Implementation	Held	35%
		Not implemented	65%
2	Learning Media	Internet	45%
		Chat/Discussion	35%
		Videos	13%
		Conference Application	7%
3	Motivation to learn	Motivated	61%
		Not enough	36%
		Enough	3%

According to questionnaire results, the majority of respondents stated that the land surveying technique practicum was not implemented. Although some respondents stated that the practicum was still held, most likely the respondents assumed that the practicum was carried out by the learning implementation of land surveying techniques learning is filled with the provision of material sourced from the other methods, not the practicum. The is no data on respondents using other learning media, this assumption is based on learning regulations throughout the COVID-19 pandemic, which prohibited learning activities at VHS. Furthermore, the learning implementation of land surveying techniques is only taught with the provision of material sourced from the internet, discussions in chat media, the provision of learning videos or using videoconferencing. Some of these alternatives can indeed be a solution at the beginning of the pandemic, but other media are needed that can make students play an active role in order to carry out a practicum. Then, the majority of students have the motivation to carry out learning, but not a few are also lacking in motivation.

Vocational schools find it difficult to transfer practical learning acquired at school to students' homes. As a result, students do not acquire skills, especially land surveying skills. Land surveying is one of the productive skills that must be learned by civil engineering students in VHS. Land surveying is part of geodesy, which studies the earth's surface by measuring an area, which is then visualized on a map (Iriani & Wicaksono, 2021). These skills are taught using ground measuring tools, such as leveling and theodolite, which are expensive and difficult for students to obtain.

According to preliminary data collection findings, along with the policy of distance learning, the learning method and media applied by distributing materials and assignments online make students less able to understand the material. Thus, the average value of student learning outcomes has not been maximized and does not meet the minimum graduation criteria because students do not understand the material without practice. One strategy in learning can be implemented by implementing a collaborative practicum with learning media (Nichols Hess & Greer, 2016). Learning multimedia includes audio narration, pictures, videos, animations, and combinations of these media that can be utilized by instructors to enhance learning (Kuswanto et al., 2021; Mahdum et al., 2019; Roemintoyo et al., 2022; Roemintoyo & Budiarto, 2021). Multimedia is capable of displaying complex materials with interactive designs, such as the use of graphic data, animation, and experimental simulations (Prayogi et al., 2019; Suhairi et al., 2020). If it has anything to do with the issue of online practicum learning, the type of multimedia that can be a suitable solution is simulation-type multimedia. Multimedia simulation can provide an imitation or representation of environmental reality in a multimedia format. These types of multimedia can be alternative solutions that are suitable for practical subjects, which directly practice procedures in carrying out a job, such as land surveying.

With so many activities outside the classroom and the need for the proper training tools, acquiring skills involve more than just reading texts (Tine et al., 2017). Integrated simulation-based learning media must be developed to support practical learning for vocational students. A learning model called simulation-based learning is designed to complement students' practice outside of the classroom (Karadogan et al., 2010). Simulation is defined as the representation of the real world in an artificial environment. The use of simulation-based learning helps students learn concepts more clearly and efficiently (De Jong & Van Joolingen, 1998). Simulations that are integrated with learning multimedia can help the learning process and motivate students to increase their knowledge (Arantes do Amaral & Hess, 2018).

In recent years, there have been many applications and websites as a source for learning (Hafeez, 2021; Osadebe & Osadebe, 2020). In fact, many applications can be used for free and downloaded on the Google Play Store and Appstore, which means it is almost certain that some of these applications have passed due diligence so that they can be utilized in educational activities by both teachers and students (Camilleri & Camilleri, 2017). Practice-based learning for vocational students requires a complete and integrated facility with technology to ensure overall psychomotor competence. Applications or learning media that can facilitate practical learning are expected to be positively impacted students' academic achievement (Huwaidi et al., 2021; Wu et al., 2017).

The number of integrations of simulation model integrations with learning media as virtual laboratories (Arantes do Amaral & Hess, 2018; Siahaan et al., 2021) increased significantly during the pandemic. Various studies have identified the impact of using virtual facilitation for practical learning. However, developing a virtual laboratory is quite complicated for teachers and takes a long time to build. Multimedia is a technology that is often used as a medium of learning lately. Many researchers and teachers have found an easy and suitable way to develop multimedia to achieve learning objectives (Gunawardhana & Palaniappan, 2016; Ljubic et al., 2020). Numerous previous studies have proven that multimedia can also play a role in supporting simulation activities, such as multimedia, which has proven to be an attractive learning medium because it is easy to create and implement (Chipangura & Aldridge, 2017; Ma, 2021). Regarding the simulation that represents an object and the work environment (Ferdiansyah et al., 2021; Qu, 2018), multimedia can also improve learning motivation (Issa et al., 2013). Multimedia can also provide a lot of information and experience to students, such as the laboratory environment (Sriadhi et al., 2021; Wang et al., 2019). Multimedia simulation can also represent the environment and objects of a laboratory or workshop (Sarsar et al., 2021).

Based on the explanation above, many previous studies have proven the effectiveness of multimedia and simulation in various fields of study. However, as far as we know, only a few studies have concentrated on multimedia simulation for practical learning of land surveying subjects in VHS. This study focuses on implementing multimedia simulations to improve students' learning outcomes in land surveying. Multimedia integrated with practical learning simulation can help students master skills anywhere and anytime. This research is certainly different from several studies that have been carried out, with reference to various theories and relevant research. This research will try to combine several elements, such as practice-based subjects, and learning media in an interactive multimedia format. These two elements will be combined with the hope of facilitating students to learn practical skills, only through interactive multimedia applications that are currently easily accessible and run by students.

Therefore, this study's objective was to acquire information about the feasibility of multimedia simulation from the experts', teachers', and students' perspectives, as well as to figure out how multimedia affects students' learning outcomes in civil engineering in VHS.

2. Methodology

2.1. Research Design

The methodology of this research was designed based on Alessi and Trollip's (2001) multimedia development model, which followed the Research and Development (R&D) methodology. R&D is a procedure used in education to build a new educational product or enhance an existing educational product. This research produced an educational product, namely simulation-based interactive multimedia. It is created to understand the concept of operating a surveyor's level, a tool used in surveying to measure the height of distant locations in comparison to a reference point or benchmark. This concept should be taught to civil engineering students in VHSs. The R&D procedure is shown in Figure 1.

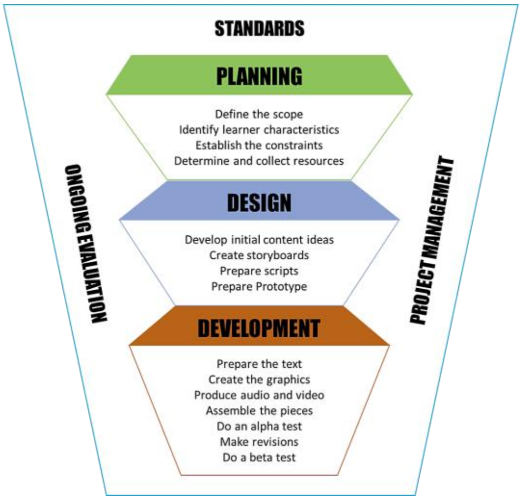

Figure 1: R&D Model of Alessi and Trollip (2001)

This development model has three phases, i.e., planning, design, and development (Alessi & Trollip, 2001). The planning stage focuses on selecting indicators and learning objectives. The design stage explains the process of creating multimedia products. The product feasibility assessment by learning experts and practitioners was referred to as the development stage. In this study, the discussion focuses on the development stage by displaying the results of multimedia product designs.

2.2. Research Subject and Data Collection Tools

The participants of this research included learning practitioners, such as instructors and students, as well as validators, such as material and media experts. This study involved 2 media experts, 2 material experts, 4 teachers, and 132 students of civil engineering VHS in Surakarta, Indonesia. The research data were collected using questionnaires and learning outcomes assessment through tests that consist of pre-test and post-test (Cresswell et al., 2003). The questionnaire data analysis techniques used descriptive analysis, while quantitative analysis used independent sample *t*-test after collecting the pre-test and post-test results. Before using the instrument, its reliability and validity must be evaluated. Pearson's validity test on each item got a value greater than $r_{table} = 0.361$ ($N = 30$; $df = N-2 = 28$). Then, the Cronbach alpha reliability test obtained a value of 0.82, which is greater than the acceptable coefficient (≥0.70). These results indicate that the validity and reliability of the instrument have been met so that it can be used to collect research data.

2.3. Research Instrument

Meanwhile, the instrument used in the feasibility questionnaire or expert validation for material experts, media experts, teachers, and students, refers to the items of the instrument previously developed (Smaldino et al., 2012). As for the instrument for measuring the effectiveness of learning outcomes, the researchers adopted several relevant studies, which have been adapted to research needs. Tables 2–4 present the product validation instrument grid.

Table 2. Material Expert Multimedia Product Validation Grid

Experts	Aspect	Amount of questions
Material	Subject matter	4
	Pedagogy	5
	Affective considerations	2
	Auxiliary information	2
	Supplementary materials	1
	Total	14

Table 3. Media Expert Multimedia Product Validation Grid

Experts	Aspect	Amount of questions
Media	Interface	4
	Navigation	4
	Invisible features	2
	Robustness	2
	Total	**12**

Tabel 4. Grid of Teacher and Student Questionnaire Instruments

Aspect	Indicator	Questions number	
		Positive (+)	Negative (-)
Subject matter	1. Material suitability	1	-
	2. Structural suitability	2	-
	3. Content selection accuracy	-	3
	4. Style and grammar	4	-
Pedagogy	1. Delivery technique	23, 24, 25	-
	2. Rating and feedback	26, 27, 28	-
Affective considerations	1. Curiosity	8, 10	-
	2. Motivation	9, 14	-
Auxiliary information	1. Introduction	6	5
	2. Instructions for use	7	-
Supplementary materials	Support material	13	12
Interface	1. Display	11, 15, 16	17
	2. Colour combination	18	-
	3. Image selection	19	-
	4. Audio and video quality	20	-
Navigation	Page switching	22	21
Invisible features	Other app glitches	-	29
Robustness	Application resistance	-	30

2.4. Data Analysis

The multimedia product assessment questionnaire comprises several questions on a Likert rating scale (4 = strongly agrees, 3 = agrees, 2 = doesn't agree and 1 = strongly disagrees). The results of the questionnaire are then analysed using the following formula below (Bustanil et al., 2019):

$$P = \frac{\sum x}{\sum xi}\ x\ 100\%$$

Formula explanation:

P : percent anticipated value

$\sum x$: total score

$\sum xi$: maximum score

The category of media validation will be shown by the calculation's percentage findings. The criteria for deciding the feasibility of multimedia simulation are used as bases of evaluation and the foundation for improving multimedia adjusts from several reference sources, such as research by Bustanil et al. (2019) and Perdana et al. (2021).

Table 5. The criteria of feasibility for multimedia development

Percentage Range	Category
80,0 - 100,0%	Very Feasible
60,0 - 79,9%	Feasible
40,0 - 59,9%	Less Feasible
20,0 - 39,9%	Not Feasible

The control and experimental classes are divided into the pre-test and post-test. The two test results were then examined using the independent sample *t*-test. The evaluation of the experimental data led to the selection of a test based on the following criteria:

H0 : there is no significant impact on improving students' learning outcomes

Ha : there is a significant impact on improving students' learning outcomes

Decision making can be done by:

- Value of sig. < 0.05 or if $t_{count} > t_{table}$, then Ha is accepted and H_0 is rejected
- Value of sig. ≥ 0.05 or if $t_{count} < t_{table}$, then Ha is rejected and H_0 is accepted

3. Results and Discussions

3.1. Results

The Alessi and Trollip (2001) multimedia development model were used to create multimedia simulations. In this section, the stages of development will be presented, which consist of product feasibility tests by experts and product effectiveness tests by students as media users.

First, material experts, media experts, teachers, and students will present the findings of the feasibility test. This multimedia contains the introduction and operation of a surveyor's level land surveying tool. This subject is taught to first-year students of civil engineering at VHS. All multimedia components are constructed using PowerPoint, iSpring suite 10, Google Forms, and apk builder. The software selection is based on ease of use and flexibility of multimedia access to be opened on various types of smartphones. This multimedia has the advantage of presenting material using text, video, audio, and land surveying practical learning with simulation content designed to represent real-world activities. In Figure 2, the application display is shown.

Figure 2: Display of multimedia simulation

Before being tested on students, multimedia must be validated by teachers, material experts, and media experts. According to the validation results, it is possible to be concluded that the multimedia simulation is feasible to be applied in the practical learning of land surveying subjects. Table 6 display the assessment findings.

Table 6. Experts and teachers' assessment findings

Validator	Percentage Value (%)	Interpretation
Material expert 1	89,25	Very Feasible
Material expert 1	89,25	
Media expert 1	73,25	Feasible
Media expert 2	75,00	
Teacher (practitioner) 1	92,25	Very Feasible
Teacher (practitioner) 2	87,50	
Teacher (practitioner) 3	93,25	
Teacher (practitioner) 4	88,50	

After using multimedia, students were asked to rate multimedia based on the assessment of several aspects of the multimedia development assessment (Alessi & Trollip, 2001). Table 7 shows students' opinions about multimedia simulation developed by researchers and obtain a score of 80.03% in the 'very feasible' criteria.

Table 7. Student assessment of multimedia

Aspect	**Percentage (%)**	**Interpretation**
subject matter	81,75	Very Feasible
pedagogy	79,75	Feasible
affective consideration	83,50	Very Feasible
auxiliary information	79,00	Feasible
supplementary materials	70,00	Feasible
interface	80,50	Very Feasible
navigation	82,00	Very Feasible
invisible features	82,75	Very Feasible
robustness	81,00	Very Feasible
Average	**80,03**	**Very Feasible**

Following the validation process related to learning media was carried out, the results were obtained if the interactive media for practical learning in simulation format was included in the proper or feasible category for use as learning media, and then the next step was to implement and use it in learning activities.

The next set of data is about the test of the multimedia simulation effectiveness on student learning outcomes, the test scheme using the control and experimental class. The continued instruction in the experimental class will utilise the products that have been successfully developed. Meanwhile, in the control class, students will learn using media and learning methods commonly used by teachers.

All data between the experimental and control classes were statistically analysed after the pre and post-test. The proposed null hypothesis was evaluated to see if there were significant differences in learning outcomes between the control and experimental classes.

Table 8. Independent sample *t*-Test

	t	**df**	**Sig. (2-tailed)**	**Mean Diff**	**Std. Error Diff**	**95% Confidence Interval of the Difference**	
						Lower	**Upper**
Equal variances assumed	22.30	132	.00	39.31	1.76	35.82	42.80
Equal variances not assumed	22.23	128.58	.00	39.31	1.77	35.81	42.81

The assessment results in Table 8 show that multimedia simulation has a significant impact on improving VHS students' practical learning outcomes. The statement is proved by the accumulation of scores according to the results of statistical tests, specifically the value of sig. (2-tailed) 0.00 < 0.05 or t_{count} (22.30) > t_{table} (1.66), with the decision of the Ha test being accepted, which states that the mean of the experimental and control classes significantly differs. In addition, the average post-test score of the experimental class was greater than the control class (71.92 > 52.33). These results show that learning land surveying techniques with multimedia simulation is more effective than non-multimedia classes. There is a significant mean difference between the two classes of 19.59. This is consistent with earlier research results that indicated multimedia had a strong potential to enhance students' skills. Table 9 compares students' average pre-test and post-test scores.

Table 9. Post-Test descriptive statistical analysis results

Class	**Mean**	**df**	**Std.**	**Sig.**	**Difference**	**Trends**
Experiment	71.92	65	4.543	Significant	19,59	Enhancement
Control	52.33	69	9.440			

Table 9 showed the post-test descriptive statistical analysis results of the experimental class were significantly enhanced than the control class (71.92 > 52.33). These results indicate that learning land surveying techniques using multimedia simulation is more effective than classes without using multimedia simulation.

3.2. Discussions

According to validation from experts, teachers, and students, multimedia simulation gained the 'good' category. This concludes that using multimedia simulation as a learning tool to support the practice of land surveying is appropriate. Students have a positive overall perception of their education. Students believe that the information provided is relevant to their needs for practical learning, which increases their motivation to learn and makes it easier for them to access and interact with the multimedia simulation content. This is similar to earlier research, which states that students gain new skills and experience because of the specified exposure (Bowyer et al., 2014; Ziadat, 2019). Interventions received and practiced using learning media have the potential to change the attitudes and understanding of the material, especially if multimedia is combined with innovative and varied approaches, such as interesting and engaging simulations (Mosler et al., 2020; Nurhikmah et al., 2021; Qu, 2018). Using simulation as a learning medium has advantages, such as being more flexible and reproducible if students want to learn outside of school (Ding & Gao, 2022; Karadogan et al., 2010; Ma, 2021). It is interesting to know that a simulation approach with multimedia can increase student motivation (Agyei & Agyei, 2021; Arantes do Amaral & Hess, 2018; Cromley & Lawrence, 2018). Thus, teachers must be able to use simulation multimedia to improve student practical learning outcomes and ensure that learning objectives are met optimally.

A comparison of students' practical learning outcomes proves that land surveying practice learning with multimedia simulation is better than traditional methods with the help of instructional videos alone. The claim that the inclusion of a case study that encourages student participation can change behaviour is supported by the observation that students typically learn best in settings that closely resemble real-world situations or hands-on learning experiences (Cantor, 1997; Pai et al., 2014). Multimedia case studies help students ability to understand more difficult and problem-solving information (Alberts & Stevenson, 2017; Nakpong & Chanchalor, 2019). Students' understanding positively increases with interactive multimedia (Amelia & Harahap, 2021; Komalasari et al., 2019; Widodo et al., 2020). Additionally, simulations in multimedia can be used as an effective assessment tool, let alone integrated with learning media, such as multimedia (Pilegard & Mayer, 2016).

The development of learning products, such as simulation-based interactive multimedia, is one of the important issues to be followed up on and disseminated. This is because facilitated learning, both theoretically and practically, it is expected to improve the quality of graduates so that they are skilled and have the competencies needed for the business and industrial aspects (Dwi et al., 2016; Mahmudah & Santosa, 2021). Realizing how swiftly technology is progressing in many fields is crucial in order to integrate it into the practical learning process (Amin et al., 2021; Saputri et al., 2020).

This is also the reason why this simulation is suitable as an alternative approach that can be implemented in VHS student learning. Then, based on the findings of this research and all of the theories discussed, simulation-based multimedia can be a learning media solution that effectively supports student skills. Learning media innovation must continue to be invented and implemented for students who need a practical learning approach to equipment in the workplace in order for the learning process to engage, stimulate, and improve student practical learning outcomes, especially for VHS students.

4. Conclusion and Recommendation

Based on media feasibility test results, the multimedia simulation was classified as feasible for use as a learning medium for the land surveying subject. The analysis of practical learning outcomes proved that multimedia simulation can improve students' practical learning outcomes compared to traditional methods. As a result of the two analyses, it is possible to be concluded that multimedia simulation provides a number of benefits and is feasible for being used as a learning media for practical learning land surveying practices in VHS.

The reader must determine whether the results can be generalised to all pertinent subjects and research objects since this study was limited to a small number of VHS in one country. However, this study offers new perspectives on instructional media that can help practical learning for VHS students. As explained in the introduction section, interactive multimedia technology has advantages in learning. This research may be an example for educators and researchers when creating practical learning media like multimedia simulation to enhance the learning quality in VHSs. Learning technology development and implementation must continue for VHS students, who require various innovations in learning equipment and media to meet industry needs.

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