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Development of Android-based virtual laboratory media at vocational school: effects on students' cognitive skills

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ABSTRACT

Vocational school students are not only required to master competency skills but also cognitive skills. Engineering mechanics learning is a basic calculation lesson that students should master. This research aimed to develop and identify the effectiveness of Android-based virtual laboratory (V-lab) media to improve students' cognitive skills in learning engineering mechanics at vocational school in Surakarta. The subjects comprised 70 students of first grade vocational school majoring in civil engineering in Surakarta. This research was a research and development (R&D) study to develop an Android-based virtual laboratory media. Testing the N-Gain analysis in the experimental and control classes was to determine the effectiveness of virtual laboratory media in improving students' cognitive thinking skills. Data were obtained from questionnaires and pretest and post-test test sheets. The developed virtual laboratory media was considered 'very appropriate' by media, material, and practitioner experts. The average value of N-Gain for the experimental class was 78.19% which was included in the effective category. Meanwhile, in the control class, the average N-Gain value reached 54.07%, which was included in the less effective category. This indicates that the use of Android-based virtual laboratory media for learning is more effective than conventional learning media.

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1. INTRODUCTION

Vocational secondary education is education at the secondary level that prioritizes the development of students' abilities to carry out certain types of work [1]. Vocational high school aims to prepare students to enter the world of work so that the absorption of graduates, the waiting period, and the first salary become the indicators of effectiveness [2]. Besides prioritizing competency skills, students are required to master cognitive skills. Previous research examined the effects of vocational high school outcomes on the world of work and revealed that students who possess vocational skills and knowledge have a positive effect and better integration into the labor market [3]. Another research also found that cognitive competence affects students' performance when they enter the world of work [4]. Vocational schools equip students with knowledge and skills in various subjects in accordance with their major to prepare them for entering the world of work. One of the subjects is engineering mechanics, which is the main field of science for the behavior (deflections and forces) of structures or machines against loads on the structures [5], [6].

Learning engineering mechanics in the classroom has to be considered as this subject is the basis for calculating the calculation material in other subjects. Preliminary observations were made to determine how engineering mechanics was taught in class. During the observation, questionnaires were distributed to the first-grade students majoring in civil engineering at State Vocational School 2 Surakarta, Indonesia. Based on the observations, students stated that engineering mechanics learning is difficult (58.33%), boring (79.17%), and they do not understand the basic material in this subject (54.17%). Feelings of boredom, lack of understanding, and not mastering basic material can affect students' cognitive understanding of engineering mechanics learning if there is no immediate handling. Based on the problem above, it is important to find the solution to the engineering mechanics learning, especially in the initial material of composition of forces on the building structure. Students are guided to understand and apply the science of special engineering mechanics to the forces of building structures.

In classroom learning, the learning media used are books and power points to explain the materials. This makes the students feel bored and less interested in learning engineering mechanics so the learning outcomes are less optimal. The student's lack of understanding of the composition of forces in building structures can be addressed by utilizing science and technological developments. The involvement of technology in the learning process has been proven effective in increasing the level of students' understanding [7]. One of the technological development that the community has widely used is smartphones [8].

Smartphones cannot be separated from students' daily life. Almost all levels of society including students choose to use Android-based smartphones as it is an ideal platform for delivering learning materials to students in the form of applications [9]. Based on the results of initial observations, all students of first grade civil engineering at State Vocational School 2 Surakarta already have an Android-based smartphone. Therefore, the researcher suggests the development of virtual laboratory (V-lab) learning media that can be accessed through Android-based smartphones.

The virtual laboratory learning media can display complex and long calculations to be simple [10]. The virtual laboratory also provides visualization of the practice directly or traditionally [11], but students do it in computer software [12]. Virtual laboratory serves as a means to assist students in pre-lab preparation, strengthen students' conceptual understanding, and substitute or complement the real laboratory [13], [14] which increases students' achievement [15]. The use of virtual laboratory makes students more active [16], reduces monotonous interactions, and enriches students' learning experiences [17]. Virtual laboratory was chosen to instill an understanding of the material and provide hands-on experiences to students.

Various learning models are useful for achieving learning objectives, especially to help students understand the materials. The virtual laboratory development used a syntax project-based learning model that engages students in knowledge construction by asking them to complete meaningful projects and develop real-world products [18], [19]. The project-based learning integrated into the learning process can provide students with in-depth understanding, help students integrate and develop collaboration and execution skills [20], and improve students' problem-solving skills [21].

Based on the elaboration above, learning engineering mechanics is difficult and boring. If it is not resolved, it will affect students, including students' cognitive skills. Vocational high schools need learning innovations such as learning media that can instill the concept of machine learning by developing a virtual laboratory learning media to provide explanations of material and variations of media in learning. The use of project-based learning (PjBL) syntax in media development is expected to provide meaningful learning to students. This research aims to identify the effectiveness of an Android-based virtual laboratory learning media in improving students' cognitive skills in learning engineering mechanics at vocational school Surakarta.

2. RESEARCH METHOD

This research was conducted at Vocational School Surakarta involving 70 students. The sampling was carried out on the entire study population, namely all students in the two classes of civil engineering expertise program. This research and development (R&D) adapted Alessi and Trolip's media development model. The adapted model covered planning, design, and development [22]. Development refers to the whole process of production, testing, improvement, and program validation by media experts, material experts, and practitioner experts. The developed model was tested on students before determining the final product to be tested in the real class. Data were tested using the alpha, beta, and effectiveness tests using the N-Gain score analysis. The percentage of instrument validity was obtained from the average questionnaire score using a Linkert scale evaluation with criteria as 4 (Strongly agree), 3 (Agree), 2 (Disagree), and 1 (Strongly disagree) [23]. The analysis of the results is formulated in (1).

$$NP = \frac{R}{SM} \times 100\% \tag{1}$$

where, NP is searched/expected percent value; R is assessment raw score; SM is ideal maximum score; and 100 is fixed number.

Based on the results, the validity of the instrument developed by the researcher can be identified. The evaluation instrument is considered appropriate if the interpretation is 61%. The tested media were considered suitable for use. Then, the media were used in classroom learning to improve the students' cognitive skills at Vocational School Surakarta majoring in Civil Engineering. The criteria for interpretation of the evaluation scores are: very appropriate (81%-100%); appropriate (61%-80%); moderate (41%-60%); less appropriate (21%-40%); and not appropriate (0%-20%) [24].

3. RESULTS AND DISCUSSION

3.1. Planning stage

The planning stage covers the scope and boundaries of product development. The researcher took some steps at this stage such as determining the scope of the virtual laboratory media, identifying the character of students as the targets for media development by proposing questions about students' opinions on learning mechanics in the classroom, and setting boundaries in the development and specifying each aspect of the development. This stage is carried out to ensure that the development of the virtual laboratory media aligns with the needs of students and teachers in the learning process.

3.2. Design stage

The design stage is the preparation of procedures for designing the content and design to complete product development. At this stage, the preparation was in the detail of the entire media product. The researcher developed ideas from the planning stage and created a flowchart of the media to be developed. The flowchart is the control flow and program structure of the developed media [25]. The Android-based virtual laboratory media development flowchart is presented in Figure 1.

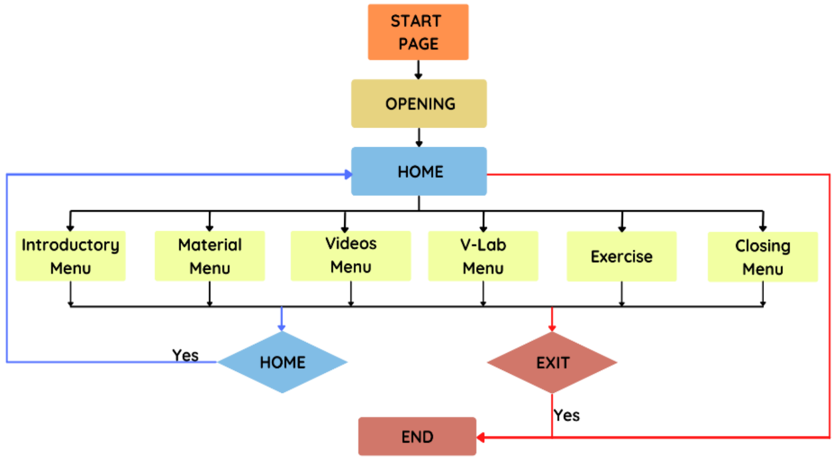

Figure 1. Android-based virtual laboratory media development flowchart

3.3. Development stage

The development stage is the implementation of the design stage covering media production activities ranging from computer programming, text production, graphics, audio, video, and media usage guides. Development refers to the entire process of program production, testing, improvement, and validation. The goal is to translate the instructional design previously prepared in the earlier stage into a tangible product that can be used by learners.

3.3.1. Media product development

First, producing learning media products was based on Android applications. The researcher made initial products using software that is very familiar to the public, so this product is easy to develop by anyone but not many people know about this method. The virtual laboratory used Phet Simulation packaged in one application. Researchers used PowerPoint software and then converted it to HTML5 using Ispring Suite 9 and converted it into an Android-based mobile apps application using the WEB2APK builder. The mobile app development can be seen in Figure 2.

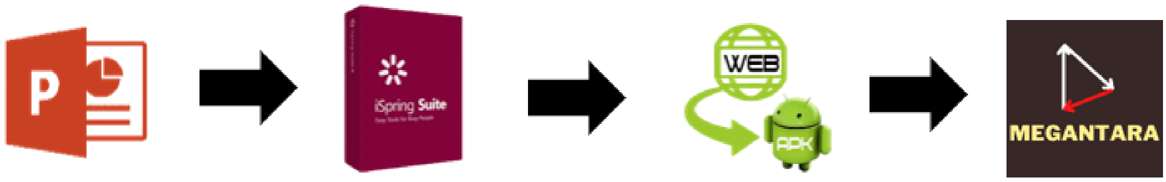

Figure 2. Mobile app development

This media has the advantage of visualizing the calculation of the composition of forces using the virtual laboratory. Besides, in one application, students do not only open the virtual laboratory but can access the material menu, learning videos, and questions in one application. The syntax project-based learning used in the development assists students in solving problems and providing in-depth understanding in order to improve students' cognitive skills. The application display can be seen in Figure 3.

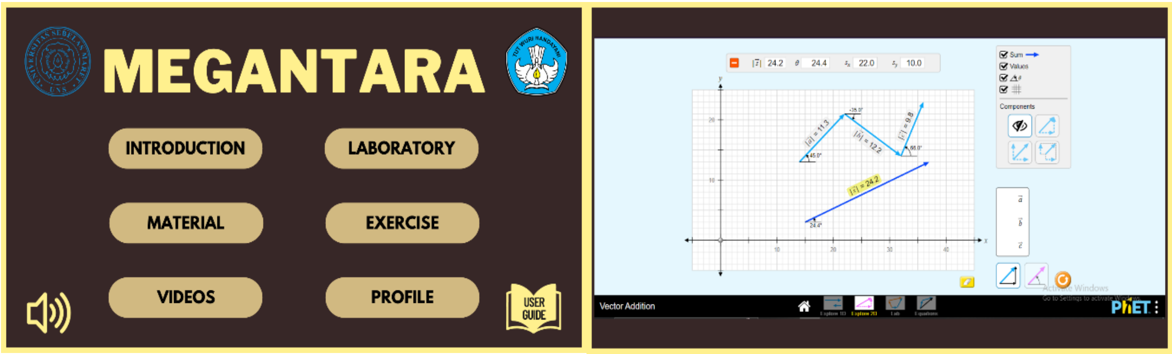

Figure 3. Virtual laboratory media display

3.3.2. Alpha test

To obtain the results of the alpha test on this media need expert judgment: two media experts to assess the content and objective, instructional, and technical aspects; two material experts to assess the correctness of the content and learning aspects; and three expert practitioners to assess appearance, content and purpose, and usefulness aspects. Besides, expert practitioners also assess material aspects and material benefits. The results of the expert validation assessment showed that media experts, material experts, and practitioners stated that the developed media was considered "very appropriate". The results of the assessment are presented in Table 1.

Table 1. Results of expert assessment recapitulation

Not.	Expert validator	Percentage value	Interpretation
1	Media 1	93.0%	Very appropriate
2	Media 2	88.0%	
3	Material 1	90.0%	Very appropriate
4	Material 2	92.0%	
5	Practitioner 1	93.5%	Very appropriate
6	Practitioner 2	90.0%	
7	Practitioner 3	95.5%	

3.3.3. Beta test

To obtain the results of the alpha test on this media need expert judgment. The beta test showed user functionality and product appearance. The results of the beta test become the basis for distributing the final product. The beta test was conducted on 70 students of Vocational School Surakarta majoring in Civil Engineering. Table 2 shows students' responses to the developed media with a score of 88.44% in the "very appropriate" criteria. The results of the student's responses to the media are presented in Table 2.

Table 2. Results of students’ questionnaire

Aspect	Number of questions	Total	Percentage
Appearance	1, 2, 3, 4, 5, 6, 7	1495	21.35%
Content and objective	8 ,9, 10, 11, 12, 13, 14	1478	21.12%
Benefits	15, 16, 17, 18, 19, 20	1628	23.26%
Technical/operational	21, 22, 23, 24, 25	1590	22.71%
Total		6191	88.44 %
Maximum	25 Questions	7000	100%

3.3.4. The use of developed media to improve students’ cognitive skills

After the media was tested and declared suitable for use, then the media were used in classroom learning to improve the students’ cognitive skills in engineering mechanics subjects at Vocational School Surakarta majoring in civil engineering. Testing the students’ cognitive skills using a pre-post control group. The recapitulation of the results of the pretest and posttest in the experimental class and control class can be seen in Figure 4.

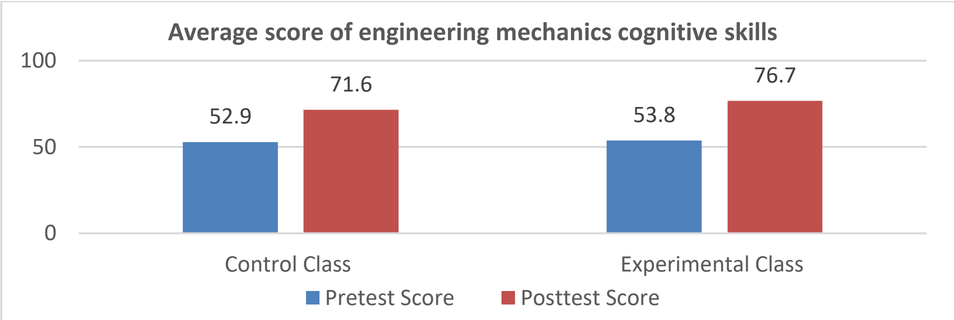

Figure 4. Average pre-test and post-test scores of students’ cognitive mechanics skills in experimental and control classes

Based on the Figure 4, there are differences in the average post-test scores for the experimental and the control classes. The post-test score of the engineering mechanics cognitive skills of the experimental class students was higher, with an average score of 76.7, while it was only 71.6 for the control class. The students in the experimental class get a higher score than the control class. The difference in the average post-test score was then analyzed using the Independent-sample T-test to determine the significance of the difference between the two classes. The results of the t-test can be seen in Table 3.

Table 3. Results of independent sample t-test

		Levene’s Test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. Error difference	95% Confidence interval of the difference	
									Lower	Upper
MT cognitive skills	Equal variances assumed	.423	.518	2.722	68	.008	5.108	1.876	1.364	8.852
	Equal variances not assumed			2.731	67.815	.008	5.108	1.870	1.375	8.840

The results of the statistical test using the statistical package for the social sciences (SPSS 25) program, the student's cognitive skills obtained a significance level of 0.008 which is smaller than 0.05 (0.008<0.05) or t-count>t-table of 2.722>1.99547. Thus, Ho was rejected and Ha was accepted which means that there is a difference in the average score between the experimental and the control class. The comparison of students' initial and final cognitive skills is summarized in Table 4.

Table 4. Results of independent sample test

Aspect	N	Std. Deviation	Significance	Difference	Trends
Experiment class	36	8.25314	Significant	-22.888889	Enhancement

Analysis of product effectiveness using N-Gain score analysis was by comparing the pretest and post-test scores of the experimental and the control groups. Based on the results of the N-Gain test in Table 5, the average N-Gain score for the experimental class is 78.19% which is included in the effective category. Meanwhile, in the control class, the average N-Gain score obtained 54.07%, which is included in the less effective category. Therefore, it can be concluded that the developed product effectively increases the competency of designing building structures compared to classes with conventional media. The N-Gain test results are summarized in Table 5.

Table 5. Calculation results of the N-Gain score analysis

Indicator	Experimental class N-Gain Score (%)	Control class N-Gain score (%)
Mean	78.1867	54.0744
Max	96.15	84.40
Min	56.64	-23.69

3.4. Discussion

The student's cognitive skills in vocational schools are very influential and useful in the world of work [4]. Previous studies have revealed that students' cognitive skills are positively related to operational ability, resilience, and competition [26], [27]. Students' cognitive skills in engineering mechanics have to be considered. The Android-based virtual laboratory learning media are proven to improve students' cognitive skills in engineering mechanics subjects. This is in line with previous research that using mobile learning media effectively influences learning outcomes [28]. Another research showed that the development of Android as learning media can make learning more attractive, fun, and interesting [29].

Vocational students majoring in civil engineering also receive subjects to equip them with skills and knowledge to be ready for the world of work [30], One of the subjects is engineering mechanics. Students need to master both competency and cognitive skills. The developed virtual laboratory learning media can facilitate students to present visual illustrations of the calculation of the composition of forces. Another research [31] showed that Virtual laboratory-based learning media have a more positive effect on students' problem-solving skills than conventional methods. It is because Android-based learning media can display attractive designs, colors, texts, images, and animation [32] and significantly impact the teaching and learning environment [33]. The use of syntax project-based learning in the development of learning media helps students gain a deeper understanding of theoretical concepts [34].

Learning can be facilitated in a variety of ways, not just through modules, PowerPoint, and lectures. Teachers can use virtual laboratory media to improve students' cognitive skills. The findings of this research contribute to education references and distinguish this research from other research because by combining various kinds of existing software, such as Phet, smart app creator, YouTube, and others in one application to produce effective learning media. The results of the study also provide references to teachers and schools to develop technological-based learning media because technological affordability, especially smartphones, significantly impacts learning [35].

4. CONCLUSION

The utilization of Android-based virtual laboratory learning media proves to be an effective alternative for enhancing students' cognitive abilities in engineering mechanics education. The swift technological advancements offer educators valuable tools to facilitate learning. Feedback from both students and experts regarding the developed learning media is highly positive, with media experts, material experts, and practitioners deeming it "very appropriate". A survey conducted among 70 vocational school students in Surakarta reveals an 88.44% approval rating for the Android-based virtual laboratory learning media. This medium has been successfully demonstrated to improve students' cognitive skills in engineering mechanics at Vocational School Surakarta. Statistical tests using SPSS 25 confirm the significance of this improvement, with a p-value of 0.008 (<0.05) and t-count>t-table (2.722>1.99547), leading to the rejection of Ho and the acceptance of Ha, indicating an average difference between the experimental and control groups in terms of students' cognitive skills in engineering mechanics. Additionally, the post-test scores for the experimental group (76.7) exceeded those of the control group (71.6). The average N-Gain score for the experimental group was 78.19% (effective), while the control group scored an average N-Gain of 54.07%, falling into the less effective. These findings underscore the greater effectiveness of Android-based virtual laboratory learning media compared to conventional methods. As technology evolves, it becomes increasingly important to refine laboratory media to align with the demands and advancements of the present era.

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