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An Android-based Courseware for Electrical Circuit Course: Is It Effective Implemented?

Doni Tri Putra Yanto[1,2*], Fivia Eliza[1,2], Hastuti[1], Andrian[1], Hermi Zaswita[3], Maryatun Kabatiah[4]

[1] *Electrical Engineering Department, Faculty of Engineering, Universitas Negeri Padang, Indonesia*
[2] *Electrical Power Engineering Research Group (EPERG), Universitas Negeri Padang, Indonesia*
[3] *English Education Study Program, STKIP Muhammadiyah Sungai Penuh, Indonesia*
[4] *Civic Education Study Program, Faculty of Social Sciences, Universitas Negeri Medan, Indonesia*
[*] *Corresponding author. Email: donitriputra@ft.unp.ac.id*

ABSTRACT

This study investigates the effectiveness of Android-based Courseware (AC) in teaching electrical circuits to vocational students in higher education. The courseware was developed using Android Studio and was implemented in the Electrical Circuit Course (ECC) at the Industrial Electrical Engineering study program, at Universitas Negeri Padang, Indonesia. The study utilized a pre-experimental design with a one-group pre-test-post-test design involving a group of students who used the AC in the learning process. The effectiveness of the AC was evaluated based on the differential analysis of pre-test and post-test scores using the paired-sample t-test. Furthermore, Cohen's d effect size analysis was used to determine the effect size. The results showed a significant difference between the post-test and pre-test scores, with the post-test scores being higher than the pre-test scores. This indicates that the courseware is effective in improving the learning process. Additionally, the effect size analysis results show that the effect of using the courseware falls within the large category. These findings suggest that AC can be an effective tool in teaching ECC and can improve student learning outcomes.

Keywords: *Android-based Courseware, Electrical Circuit Course, Effectiveness Analysis, Vocational Students.*

1. INTRODUCTION

The Covid-19 pandemic that occurred demanded rapid changes in the implementation of learning in vocational education. The implementation of learning that was previously carried out face-to-face in class has changed to distance learning. Changes that occur so quickly require educators in vocational education to continue to innovate in the learning process and be adaptive to the changes that occur. These innovations can be in the form of innovative models, methods, strategies, and learning media that can be applied in the learning process.

Electrical Circuit Course (ECC) is one of the subjects that vocational education students in the field of industrial electrical engineering at the Faculty of Engineering, Universitas Negeri Padang are required to study. In this course, students learn about basic concepts such as resistance, capacitance, inductance, electric current, and electric voltage. This ECC is crucial as the concepts learned are highly relevant to the needs of the industrial world. Hence, the course must be conducted optimally to achieve its objectives.

ECC revealed some problems, which include: (1) Accessibility limitations: students have difficulty comprehending the latest electrical circuit concepts because they lack access to laboratories or adequate practical equipment for the latest and industry-relevant electrical circuit technology [1], [2]; (2) Interaction limitations: students face difficulty interacting with lecturers or instructors during the learning process due to a large number of students in one class, which prevents the lecturer from responding to specific questions in full[3]; (3) Limited availability of place and time: the available learning media has been insufficient in overcoming the problems of limited space and time, whereas the electrical circuit material is complex and requires comprehensive understanding[4], [5]; (4)

Unavailability of learning media that can facilitate distance learning, which is increasingly popular after the Covid-19 pandemic, and the demands of 21st-century learning that require flexibility. These problems have resulted in the sub-optimal learning process in the ECC and low student learning outcomes [1], [3].

The previous research has demonstrated that interactive learning models, project-based learning, and problem-based learning can address learning challenges. Moreover, selecting and utilizing appropriate learning media play a vital role in tackling learning difficulties[6]–[9]. An interactive learning medium, presented as an Android application, is an innovative learning approach chosen to resolve learning problems in ECC. This is supported by the increasing popularity of Android or smartphone users in everyday life, which makes mobile-based learning increasingly popular [10], [11]. AC can overcome the problem of the complexity of learning material because it does not have space and time limitations. Students can learn anywhere and anytime independently, apart from guided learning in class[10], [12]. This results in a more optimal learning process, in line with the characteristics and needs of each individual in the learning process.

Before using AC as an innovative way in ECC, it must undergo several tests. These tests are carried out to ensure that the AC is feasible and effective in the learning process to solve problems optimally [7], [13]. One of these tests is the effectiveness test. The effectiveness test of AC evaluates how well the media is used in the learning process to improve student understanding and achievement[13]. The results of the test can be used to enhance the quality of the learning media used in vocational education. Therefore, this research aims to answer the following questions: (1) Is AC effectively used as a learning medium in ECC in vocational education for industrial electrical engineering? and (2) To what extent does AC affect the learning process in ECC in industrial electrical engineering vocational education?

The general objective of this study is to determine the effectiveness of AC as a learning medium in ECC in increasing students' understanding and learning achievement in vocational education. The specific objectives of this study are: (1) to analyze the students' cognitive abilities regarding electrical circuit materials before and after using AC as learning media; (2) to analyze the effect of using AC as a learning medium on students' cognitive learning outcomes in the electrical circuits course; and (3) to determine the magnitude of the effect of using AC as a learning medium in ECC. This research contributes to (1) providing useful information for the development of more effective android-based learning media for ECC in vocational education, (2) offering references for teachers and curriculum developers in vocational education to improve the quality of the learning process in ECC, (3) enhancing the quality of vocational education in the field of electric power engineering by optimizing the use of android-based learning media in ECC, and (4) providing references for future researchers who wish to conduct similar research on the development of android-based learning media in the field of vocational education.

2. LITERATURE REVIEW

2.1. Android-based Courseware

Android-based Courseware (AC) is a learning program or application developed based on the Android operating system, which can be used as an effective and interactive learning medium in an educational environment[14], [15]. This application offers comprehensive features, such as learning materials, video tutorials, audio, interactive quizzes, and others, which can help students understand the subject matter more easily and enjoyably [16], [17]. An AC has several advantages as a learning medium, including (1) Flexibility, as it can be accessed and used anytime and anywhere using a smartphone or tablet device that is portable; (2) Interactivity and multimedia, as it has multimedia features such as images, videos, and audio, which can enrich the learning experience and make it more interesting; (3) Immediate feedback, as it can provide direct and automatic feedback on students' answers in interactive quizzes, allowing them to immediately identify their strengths and weaknesses in understanding the subject matter; and (4) Integration with technology, as it can be integrated with other technologies such as augmented reality and virtual reality to enhance the effectiveness and efficiency of learning [15], [17]–[20].

However, An AC also has some drawbacks if not implemented optimally, including (1) Limitations of social interaction, as the use of An AC may reduce social interaction between students and lecturers, which can affect the formation of social relations in the educational environment; (2) Limited resources, as the use of an AC requires a smartphone or tablet device, which may not be available to all students; and (3) Limited technical support, as some students may face difficulties in using android-based learning applications, requiring complete technical support [14], [15], [20].

2.2. Electrical Circuit Course

Electrical Circuit Course (EEC) is a crucial subject for students pursuing vocational education in the field of electrical power engineering. The course covers fundamental concepts of electric circuits, including resistance, capacitance, inductance, electric current, and voltage [1], [5]. Students also learn about different types of electrical circuits, such as series, parallel, and mixed circuits, and techniques for analyzing them. In lectures,

students engage in practical activities to apply their knowledge of electrical circuits in measurement and analysis[4], [5]. They also participate in projects that require them to apply electrical circuit concepts to design efficient and reliable electric power systems. This course is vital to vocational education students in the field of electrical power engineering as the concepts studied are highly relevant to the demands of the industrial sector.

3. METHOD

3.1. Research Design

This research is an experimental study using a Pre-experimental Design, specifically the One-Group Pre-test-Post-test design as presented in Figure 1 [19], [21]. The pre-test is conducted prior to the implementation of the research activities to assess students' initial abilities (O1) before being exposed to the research intervention. The research intervention implemented in this study is the use of an AC as a learning medium for the electric circuits learning process (X). The post-test is administered after the implementation of the research intervention to measure students' final ability in understanding electric circuits using the AC as a learning medium.

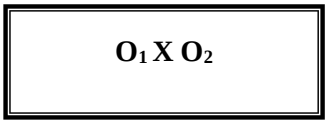

Figure 1 Research Design

3.2. Research Instruments

The research utilized a multiple-choice test as the research instrument for both pre-test and post-test assessments [21], [22]. The multiple-choice tests were developed based on basic competencies and competency achievement indicators of ECC. The research instrument underwent validity, reliability, difficulty index, and discriminatory power analyses. Validity was analyzed using the Pearson Product Moment Correlation analysis, reliability was determined using Cronbach's Alpha reliability analysis, the difficulty index was analyzed using the difficulty index formula, and the discriminatory power was analyzed using discriminating power analysis through multiple choice questions [21]–[23]. The validity analysis showed that the r-count value for all indicators was greater than the r-table (> 0.361), indicating the validity of all indicators in the research instrument. Cronbach's alpha analysis resulted in a value of 0.815, indicating that the research instrument, in the form of a multiple-choice test, is considered reliable since the value of Cronbach's alpha is greater than 0.60 (0.815 > 0.600). The difficulty index analysis shows that the difficulty index is 0.67 (in the moderate category). The discriminating power analysis showed that the discriminating power index of the research instrument tested was 0.71 (in the very good category). The tested research instrument was then utilized to measure the level of cognitive understanding of students before and after the learning process of electric circuits using AC as a learning medium.

3.3. Research Subject

This study involved a group of 47 vocational students from the Industrial Electrical Engineering study program in the Electrical Engineering Department, Faculty of Engineering at Universitas Negeri Padang, Sumatera Barat, Indonesia. All of these students participated in the study as the experimental group and followed the research procedures according to the research design, which included a pre-test, action research, and post-test.

3.4. Techniques of Data Analysis

The data collected in this research pertains to the cognitive domain of student learning outcomes. The research data is categorized into pre-test and post-test data. Prior to conducting an effectiveness analysis, normality tests were carried out using the Kolmogorov-Smirnov Z normality analysis on the pre-test and post-test data [21], [23].

The effectiveness of the AC as a learning medium for ECC was evaluated using two analytical techniques: paired sample t-test analysis and Cohen's d Effect Size analysis. Paired sample t-test analysis was utilized to determine whether there is a significant difference between the pre-test and post-test data. Conversely, Cohen's d Effect Size analysis was conducted to assess the effectiveness of the AC as a learning medium for ECC [21], [22]. All data analyses were performed using the SPSS data analysis application.

The effect size value obtained from Cohen's d Effect Size analysis is interpreted using the effect size criteria table presented in Table 1 [21], [23]. This interpretation is conducted to determine the effect category of the given research action, which is the learning process of electric circuits using an AC as a learning medium. Based on the interpretation results, the level of effectiveness of an AC as a learning medium can be determined.

Table 1. Effect Size Criteria

No.	d Value Range	Categories
1	0,8 ≤ d ≤ 2,0	Big
2	0,5 ≤ d < 0,8	Medium
3	0,2 ≤ d < 0,5	Small

4. RESULT AND DISCUSSION

4.1. Results

An AC is a learning application developed for Android operating systems, which serves as an interactive and effective learning medium in an educational environment [14], [15]. This application provides a range of features such as learning materials, video tutorials, audio, interactive quizzes, and more, which can help students comprehend subject matter more easily and enjoyably [16], [17]. The AC can be accessed by students via their smartphones or tablet devices, providing them the flexibility to study anytime and anywhere without being bound to a particular time or location, as in traditional learning. In this way, it provides students with more flexibility in studying the subject matter. For the ECC in this study, an AC was developed using Android Studio, and the output file was in the form of an Android Package Kit (.APK) to facilitate the installation process on Android devices for each student. the display features and menus on the AC developed and used in this study are presented in Figure 2.

Figure 2 The Display Features and Menus on the AC

4.1.1. Research Data

The data collected in this study is quantitative data obtained from the results of students' cognitive ability tests using research instruments in the form of multiple-choice tests. In accordance with the research design used in this study, data collection using research instruments was conducted twice, namely before (pre-test) and after (post-test) the implementation of learning in the ECC using an AC as a learning medium. The pre-test and post-test data are used as a reference for analyzing the effectiveness of using an AC as a learning medium in ECC.

4.1.1.1 Pre-test Data

The pre-test is an initial test given to students to assess their basic abilities before receiving research treatment in the form of a learning process that uses an AC as a learning medium in ECC. Pre-test data were obtained through test results on students using research instruments in the form of multiple-choice tests given to all students who were research subjects. Pre-test data is needed to carry out data analysis to determine the effectiveness of implementing an AC as a learning medium.

The results of the pre-test data analysis showed that the minimum score of students' cognitive learning outcomes before using an AC as a learning medium was 45, and the maximum score was 75, with an average score of 60 for 47 students and a standard deviation of 7.813. The pre-test data normality test was carried out first to ensure that the data was normally distributed before it could be used for effectiveness analysis using paired-sample t-test analysis and effect size analysis. The results of the pre-test data normality analysis are presented using the Kolmogorov-Smirnov Z formula, which is presented in Table 2.

The results of the normality test on the pre-test data presented in Table 2 indicate a significance value of 0.713, which is higher than the standard alpha value of 0.05. Therefore, it can be concluded that the pre-test data follows a normal distribution ($\alpha = 0.713 > 0.05$). As a result, the pre-test data can be utilized for further analysis, namely the evaluation of the effectiveness of an AC as a learning medium in ECC.

Table 2. The Results of Normality Test Analysis of Pre-test Data

		Pre-test Score
N		47
Normal Parameters[a,b]	Mean	60.00
	Std. Deviation	7.813
Most Extreme Differences	Absolute	0.100
	Positive	0.074
	Negative	-0.100
Kolmogorov-Smirnov Z		0.548
Asymp. Sig. (2-tailed)		0.713

a. Test distribution is Normal.

b. Calculated from data.

4.1.1.2 Post-test Data

The post-test is a final assessment of students' cognitive learning outcomes after completing research activities in the form of an electric circuit learning process that utilizes an AC as a learning medium. The post-test data was obtained through the test results of each student using a research instrument in the form of multiple-choice tests. This post-test data complements the pre-test data used to analyze the effectiveness of using an AC as a learning medium in ECC.

The results of the post-test data analysis showed that the minimum score for student learning outcomes after using an AC was 60 and the maximum score was 90. The average score of the 47 students was 85 with a standard deviation of 5.117. A normality test was carried out on the post-test data as a prerequisite for analysis before it could be used for effectiveness analysis using paired-sample t-test analysis and effect size analysis. The results of the post-test data normality test using the Kolmogorov-Smirnov Z formula are presented in Table 3.

4.1.3. Effectiveness Analysis of an AC

The effectiveness of using an AC as a learning medium in vocational education for ECC was evaluated through a paired-sample t-test analysis. This analysis aimed to determine significant differences in students' cognitive learning outcomes before and after participating in the learning process using the AC. The results of the paired-sample t-test analysis indicate that the t-count value (6.567) is greater than the t-table value (1.684), and the alpha significance value (0.000) is less than 0.05. Therefore, it can be concluded that there is a significant difference between students' learning outcomes in the pre-test and post-test, where the post-test students' cognitive learning outcomes are better than the pre-test students'. This is supported by the fact that the post-test students' average cognitive score (85) is higher than the pre-test average (60). Thus, it can be concluded that the AC is an effective learning medium in the learning process for vocational students in ECC.

The effectiveness of using An AC as a learning medium in the ECC in vocational education was also evaluated through Cohen's d Effect Size analysis to measure the effect size. The analysis of the effect size between the pre-test and post-test data resulted in an effective index value of 1.77 (d = 1.77). According to the effect size criteria table, this effect size is considered to have a large category of influence. Thus, based on the result of the effect size analysis and the interpretation of the effect size category, it can be concluded that An AC is an effective learning medium for use in the learning

Table 3. The Results of Normality Test Analysis of Post-test Data

		Post-test Score
N		22
Normal Parameters[a,b]	Mean	85.00
	Std. Deviation	5.117
Most Extreme Differences	Absolute	0.135
	Positive	0.079
	Negative	-0.135
Kolmogorov-Smirnov Z		0.711
Asymp. Sig. (2-tailed)		0.815

a. Test distribution is Normal.

b. Calculated from data.

The results of the normality test for the post-test data in Table 3 reveal a significance value of 0.815, which is greater than the standard alpha value of 0.05. Therefore, it can be concluded that the post-test data follows a normal distribution ($\alpha = 0.815 > 0.05$). Consequently, the post-test data can be used for further analysis, specifically an assessment of the effectiveness of utilizing an AC as a learning medium in ECC.

process in ECC, with a large effect size. Therefore, using An AC in the learning process can be an option for implementing effective learning in vocational education, especially in ECC.

4.2. Discussion

An AC is an educational application or program developed based on the Android platform, which can serve as an interactive and effective learning medium in an academic setting [14], [15]. This application has comprehensive features such as learning materials, video tutorials, audio, interactive quizzes, and more, that can assist students in comprehending subject matter more easily and enjoyably. When utilized, the AC can be accessed by students via their smartphone or tablet device [16], [17]. With this, students can study anytime and anywhere, without being constrained by time and location as in traditional learning. This flexibility offers students more options for studying the subject matter. The AC used in this study was developed based on the electric circuit course's curriculum and material, as well as the needs and characteristics of the students.

Before being utilized, An AC undergoes various testing stages, including an effectiveness test that aims to determine the extent to which the courseware can aid students in understanding and mastering the subject matter. The effectiveness of An AC was evaluated through two data analyses: a paired-sample t-test analysis and a Cohen's D effect size analysis.

The results indicate that there were significant differences in students' cognitive learning outcomes before and after using An AC as a learning medium, as shown by the paired-sample t-test analysis of post-test and pre-test data. Learning outcomes were much better after using an AC, indicating that it is an effective learning medium for vocational students in ECC. These findings are consistent with previous studies demonstrating the effectiveness of Android-based learning media or Android-based multimedia in the learning process of abstract concepts [10], [20], [23], [24]. The effectiveness of an AC can be evaluated by comparing the differences in student learning outcomes between experimental and control classes or by assessing the differences in learning outcomes before and after using the learning media [10], [14].

Based on the results of the analysis using Cohen's D effect size analysis, the effect size of using An AC as a learning medium in ECC is in a large category. This indicates that An AC as a learning medium significantly improves students' cognitive understanding in ECC. These findings are consistent with previous studies that demonstrate the significant impact of Android-based learning media or multimedia on improving student learning outcomes, as it supports independent learning without constraints of time and space [14], [15], [25]. Furthermore, An AC as a learning medium has the potential to increase student interest and motivation in the learning process. This learning medium can also serve as an alternative choice for implementing effective, innovative, and adaptive learning with technological advancements in vocational education. The use of An AC as a learning medium in vocational education, especially in ECC, will result in a more diverse learning process, thus increasing student interest and motivation at each stage of the learning process.

4. CONCLUSION

An AC is a learning program or application developed based on Android, which can be used as an effective and interactive learning medium in vocational education, particularly in ECC. It plays a significant role in optimizing the implementation of learning, particularly in supporting independent and flexible learning without any time or space limitations. The results indicate that the developed AC was an effective learning medium for ECC, where the effect size was in a large category. Its increased students' cognitive understanding of electrical circuit concepts that were previously difficult to comprehend using conventional media. Therefore, AC can be considered as an alternative choice for implementing effective, innovative, and adaptive learning with technological developments in vocational education, particularly in ECC.

LIMITATIONS AND FUTURE WORK

The study was conducted solely on ECC in vocational education; therefore, the generalization of the research results must be done with caution before being applied to different courses or levels of education. Moreover, the effectiveness test only examined students' cognitive aspects, and further research is required to investigate the effects of An AC on students' affective and psychomotor aspects. Furthermore, the research was conducted with a limited number of participants and was only conducted at one vocational education institution. Therefore, broader research is necessary to test the effectiveness of An AC on a wider population. Based on these research limitations, future work for this study includes (1) examining the effectiveness of An AC in different subjects and at different levels of education, (2) studying the effectiveness of An AC on students' affective and psychomotor aspects, and (3) conducting more extensive research to test the effectiveness of An AC in different educational institutions and with a more extensive population. Additionally, new features in An AC must be continually developed to increase its effectiveness as a learning medium in line with science and technology developments.

AUTHORS' CONTRIBUTIONS

Conceptualization: D.T.P.Y., H., H.Z., M.K.; Methodology: D.T.P.Y., F.E., A.; Validation: D.T.P.Y., H.Z., H., F.E.., MK.; Formal Analysis: D.T.P.Y., F.E., A.; Original Draft Preparation: D.T.P.Y., H.Z.; Writing Review and Editing: H.Z., M.K., Visualization: D.T.P.Y.

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