



Development of Arduino-Based Electrical Practicum e-Module

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Abstract

The development of IoT-based innovative learning media to improve student competence is needed in the era of industrial revolution 4.0. This study aims to develop an electrical practicum e-module using the Arduino Uno experimental tool to get valid, practical, and effective criteria. The research method uses R&D with four D models. The development stage consists of the stages of defining, designing, developing, and limited dissemination. Data analysis used descriptive analysis with Aiken V. The results showed that the e-module get the criteria of high validity with index $V = 0.87$. 60% of the total number of students responded positively to the media, and 40% were very active when using the media, so the modules developed were considered practical. The effectiveness level of the module shows that 100% of the students get a higher learning outcome value than the learning completeness score, so it can be concluded that the e-module has met the effective criteria.

Keyword: Arduino, e-module, Electrical

Abstrak

Pengembangan media pembelajaran inovatif berbasis Iot untuk meningkatkan kompetensi mahasiswa sangat diperlukan dalam era revolusi industri 4.0. Penelitian ini bertujuan untuk mengembangkan e-modul praktikum kelistrikan menggunakan alat percobaan Arduino Uno yang memenuhi kriteria valid, praktis, dan efektif. Metode penelitian menggunakan R&D dengan four D model. Tahapan pengembangan terdiri atas tahap pendefinisian, perancangan, pengembangan, dan diseminasi terbatas. Analisis data menggunakan analisis deskriptif dengan Aiken V. Hasil penelitian menunjukkan e-modul telah memenuhi kriteria validitas tinggi dengan indeks $V = 0,87$. 60% dari jumlah keseluruhan mahasiswa memberikan respon sangat positif terhadap media dan 40% mahasiswa sangat aktif saat menggunakan media, sehingga modul yang dikembangkan dinyatakan praktis. Tingkat keefektifan modul menunjukkan bahwa 100% dari mahasiswa mendapatkan nilai hasil belajar lebih tinggi dari nilai ketuntasan belajar, sehingga dapat disimpulkan bahwa e-modul telah memenuhi kriteria efektif.

Kata kunci: Arduino, e modul, Kelistrikan

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1. Introduction

The changing world is now entering the era of the industrial revolution 4.0 or the fourth world industrial revolution, so information technology has become the basis of human life [1]. Preparing qualified graduates who are able to compete globally and master technological developments is important for everyone and essential for the future of a country [2]. The support and role of higher education are expected to increase the competitiveness of the Indonesian nation during the rapid development of information technology.

Industry 4.0 is characterized by increased digitization of manufacturing driven by four factors: 1) increased data volume, computing power, and connectivity; 2) emergence of business analytics, capabilities, and intelligence; 3) the occurrence of new forms of interaction between humans and machines; and 4) improvement of digital transfer instructions to the physical world, such as robotics and 3D printing [3]. The basic principle of industry 4.0 is the integration of machines, workflows, and systems, by implementing intelligent networks along the production chain and processes to control each other independently [4]. The world of education must be able to adapt quickly to adapt to the development of industry 4.0.

Learning physics in the classroom should use the latest technology, one of which is a microcontroller. The electrical practicum applied so far uses measuring instruments such as multimeters and oscilloscopes. The ability possessed in using essential measuring tools is still not sufficient to accommodate current needs. The use of Arduino-based experimental tools can improve 21st-century competencies such as collaboration skills, critical thinking, and curiosity [14], [15]. Students need to be equipped with the ability to use experimental tools based on today's technology, one of which is the use of Arduino and sensors. Arduino is said to be an open-source physical computing platform. Arduino is a microcontroller device that is used for sensing, controlling, logical, and computing applications [5]. Several studies have shown the use of Arduino in various kinds of learning/measurement media, including electrical measurement tools [6], [7]. Arduino is used to stimulating curiosity, interest and hone students' problem-solving skills.

The practicum e-module in this study is a practicum module made in electronic form that can be opened via a smartphone or computer. The practicum module contains electrical experiments using Arduino microcontroller-based tools and materials. The Arduino microcontroller is used because it is easy to obtain at a low price, making it easier for students to conduct independent experiments. In learning activities, students are divided into several groups, then observe and carry out practicum. Activities like this require the latest technology that is easy and inexpensive to use by students. Arduino-based electrical practicum e-module is expected to be a tool in the learning process to be efficient and effective. The developed e-module is scheduled to meet the criteria of being valid, practical, and effective.

2. Method

The research carried out is Research and Development. The development model used is a 4-D model with define, design, development, and dissemination steps. The research procedure is presented in Figure 1. The research subjects consisted of 7 validators to test the validity of the media and 20 students to test the practicality of the media. They collected research data using several instruments, namely product validation sheets, including presentation, content feasibility, and language. Student response to the e-module using a response questionnaire. The test instrument was used to determine the average student learning outcomes after the application of the media. Aiken V validity test was used to determine the validity of the media [8], as follows

$$V = \frac{\sum s}{c(n-1)} \quad (1)$$

Where V = index of agreement of the rater (validator) regarding item validation, s = score assigned to each rater (validator), and c = number of categories that the rater (validator) can choose from.

The validity category follows the category index; if $V < 0.4$, then the validity is weak, if $0.4 \leq V \leq 0.8$, then the validity is moderate, and if $V > 0.8$, then the validity is high.

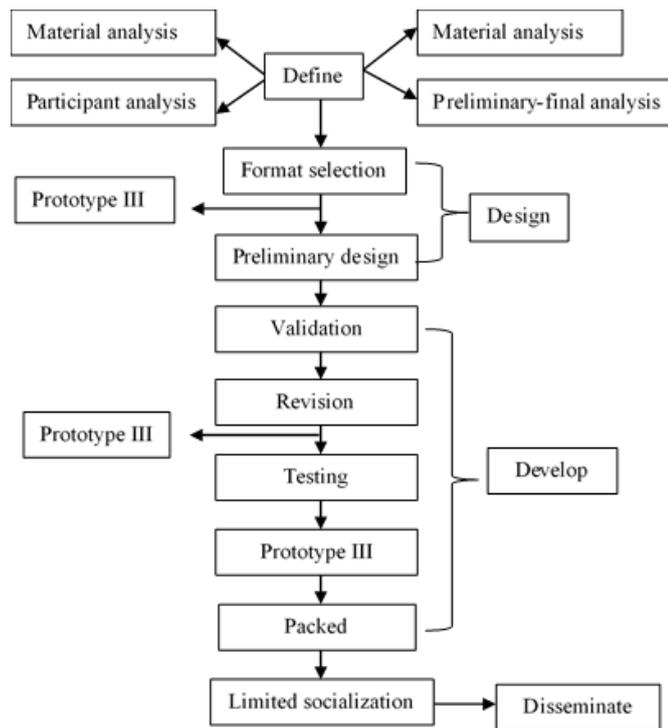


Figure 1. 4-D Model development procedure

Research data obtained from respondents' questionnaires were processed using the proportion test [9], namely:

$$P = \frac{f}{N} \times 100\% \tag{2}$$

where P is the proportion, f is the frequency of students, and N is the number of respondents. The categories of adjusted student response results are presented in Table 1.

Table 1. Categories of media practicality

Equations	Classification
$X > (X_t)^{-} + 1,8 \times sbi$	Very good
$(X_t)^{-} + 0,6 \times sbi < X \leq (X_t)^{-} + 1,8 \times sbi$	Good
$(X_t)^{-} - 0,6 \times sbi < X \leq (X_t)^{-} + 0,6 \times sbi$	Enough
$(X_t)^{-} - 1,8 \times sbi < X \leq (X_t)^{-} - 0,6 \times sbi$	Less
$X \leq (X_t)^{-} - 1,8 \times sbi$	Very less

Testing the effectiveness of the media on student learning outcomes using the criteria for completeness of learning outcomes [10]. If the score obtained is greater than 60, it is declared passed (completed), and less than 60 is declared not passed (incomplete). The media is communicated effectively if students' graduation is greater than 80% of the total number of students.

3. Result and Discussion

The define step is the first step in the development process. Define steps is the main objectives of the development of the e-module are defined, the suitability of the e-module with the student's abilities, and the selection of materials. E-modules developed on electrical material for 2nd-semester physics education students who have taken Basic Physics 1 to increase student motivation in practicum and improve skills using digital-based experimental tools. Arduino Uno and sensors were used as measurement tools in the experiment. The practicum module is an electronic version with the help of the liveworksheets.com website.

The second step is the Designed stage, which is selecting a suitable format for the practicum module. The practicum module consists of 6 experiments with the order of presentation, namely experimental objectives, theoretical studies, technical formulations that contain experimental procedures and Arduino program code syntax, experimental results, and conclusions.

At the development stage, validation is carried out. Physics learning requires good media and meets the criteria of being valid, practical, and effective. Seven validators tested the level of validity of the e-module. The indicators validated by the seven validators are presentation, material, and language—the results of the content validity assessment are presented in Figure 2, which shows that the three indicators validated by the validator meet the high level of validity with a value of 0.87. Overall, the Arduino-based practicum e-module has met the valid criteria. The practicum e-module is shown in Figure 3.

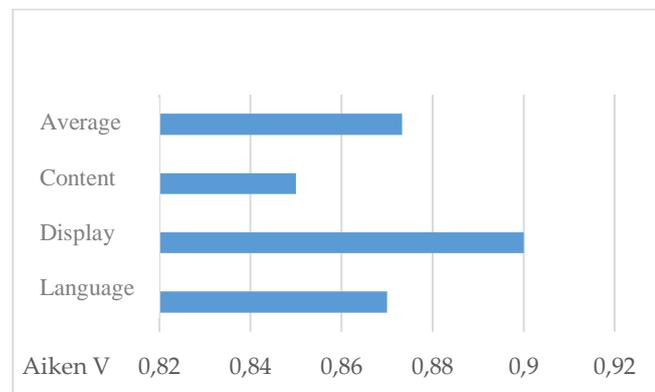


Figure 2. The average value of the Aiken-V e-module practicum index

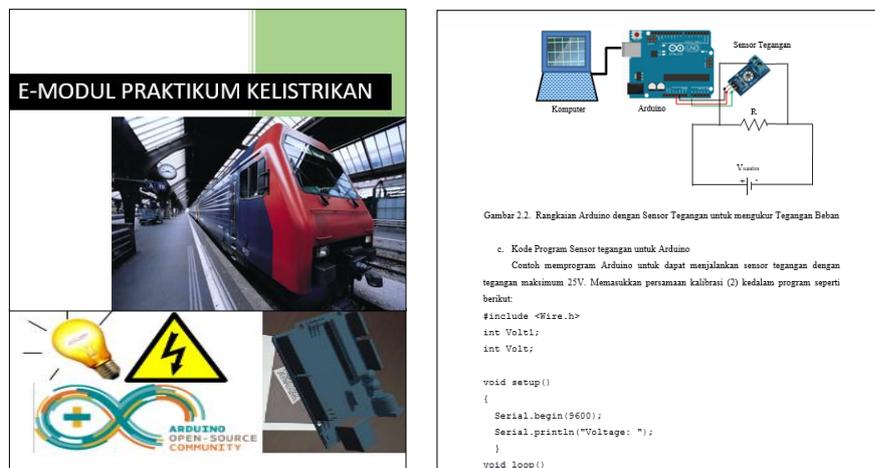


Figure 3. Front cover and one of the experiments in the practicum e-module (Prototype II)

The form of the practicum e-module has undergone several revisions based on suggestions from the validator. The valid e-module is called prototype II, which can be shown in Figure 3. The practical e-module contains electrical experiments using Arduino-based tools and materials and is then made in electronic form that opens via Smartphone. After seven validators validated the module to produce prototype II, the practicum module was used in the learning process to test the practicum module. The trial was carried out in the Physics Education Study Program, especially the second-semester students, totaling 20 people. The results of the problem are an illustration of the practicality and the effectiveness practicum e-module show on Figure 4.

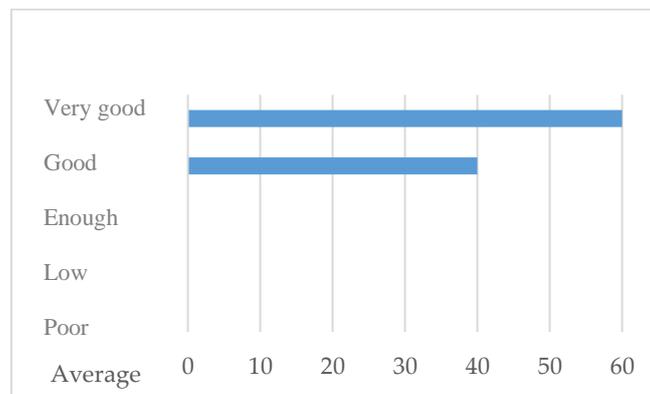


Figure 4. Student responses to e-modules

Figure 4 shows the student's response to the practicum module tested. Based on the table, 60% of the 20 students gave an excellent response to the practicum module, and the remaining 40% gave a good answer. This shows that the Arduino-based electrical practicum e-module has a positive impact on students. In addition, the results of observations on the use of the practicum module also offer the same thing, as can be seen in Figure 5.

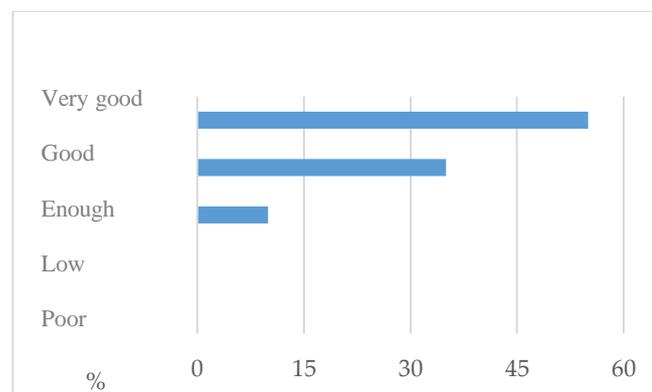


Figure 5. Results of observations on student activities when using the e-module practicum

The results of the observational analysis in Figure 5 show that of the 20 students who used the practicum module, there were 11 people or 55% of the total number of students who were very active during the learning process. This shows that Arduino-based practicum e-modules can increase student activity in the learning process.

The effectiveness of the practicum module on student learning outcomes is measured by giving tests to students after participating in learning using the developed practicum module. The value obtained by students is compared with the passing grade to see the level of effectiveness of the module. The results obtained can be shown in [Table 2](#).

Table 2. Completeness of student learning after using the e-module practicum

Range	f	%	Description
≥ 60	20	100	Graduated
< 60	0	0	Not Graduated
Amount	20	100	

[Table 2](#) shows that all students get a score greater than 60. These results indicate that the e-module is effectively applied to improve student learning outcomes [10]. Student responses, practicality and effectiveness of the practicum module obtained in this study indicate that the developed practicum e-module can improve the quality of a learning process.

The developed practicum e-module can view via Android. The practicum e-module contains Arduino-based electrical experiments complete with Arduino program syntax to be carried out independently. This e-module is very helpful for students in the learning process. This is in line with the results of previous studies, which found that practicum worksheets have a high level of attractiveness are more effectively applied [11]. Good learning media will facilitate the teaching and learning process in the classroom well [12]. An efficient and effective learning process can help students concentrate better—the concentration needed in carrying out practicals with tools in the form of an Arduino-based electrical practicum e-module.

One way to improve student learning outcomes is to confront students in a problem that students have not encountered before, and this is where the student's thinking process will emerge. An electrical practicum that has been implemented so far only uses measurement tools such as multimeters and oscilloscopes. Students are not familiar with and use microcontrollers and sensors as experimental tools. The use of Arduino in electrical practicum is new and will cause exciting problems to solve. Arduino is very helpful for students in understanding concepts in electricity. The measurement of electric current and voltage, which was initially only done using a multimeter, can be replaced with the use of Arduino and sensors. E-module practicum is very effectively used by students so that students get good learning outcomes. This is following previous research, which shows that student learning outcomes can be improved by presenting students with new things [13]. The effectiveness of the practicum e-module has an impact on business success or on learning outcomes.

4. Conclusion

The Arduino-based electrical practicum e-module was developed using the 4D research and Development (R&D) procedure. The assessment results from the validator show that the practicum e-module meets the valid criteria in the high category. Student responses to the module indicate that the practical practicum e-module is applied. The field test showed that the practical e-module was effective in improving student learning outcomes.

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