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The Development of Training Kit For Basic Electronic Control on Automotive Field

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Abstract. This study aims to determine: (1) the material needed by students in the Basic Practice of Electronic Control Systems in the automotive field, (2) the design of the Basic Electronic Control System Training Kit in the automotive field, (3) the results of the development of the Basic Electronic Control System training kit in the automotive field. , (4) eligibility of the basic training kit for the Electronic Control System in the automotive sector, and (5) users responses to the development results of the Basic Electronic Control System training kit. This study uses the research and development (RND) method. The research was carried out in 5 stages, namely: (1) the needs analysis stage, (2) the product design stage, (3) the product development stage, (4) the product use implementation stage, and (5) the product evaluation stage. Retrieval of data using documentation and questionnaires. The results showed that: (1) The materials needed by students in the basic practice of automotive electronic control systems include: understanding the use of simulation software, functions, arrays and looping on Arduino, serial communication, use of LCDs, use of interrupts, use of analog to digital converters, infrared sensor, ultrasonic sensor, pulse width modulation, lookup table function and EEPROM data writing, and arduino applications in the automotive sector; (2) The development product of the training kit is in the form of educational props containing parts of the power supply system, various kinds of input variations, the process system with Arduino Uno, and the output section in the form of lamps, buzzers, electric motors, solenoids, 7 segment displays, LCD, relays, and driver transistor. The model is packaged in a box for individual or group learning of 2-3 people; (3) The developed training kit was declared very feasible according to media experts and material experts; (4) The developed training kit received a positive response from users/students.

1. Introduction

The development of technology in the automotive sector, especially in the field of electronic control systems, is so fast. This is because modern vehicles require a variety of high comfort and safety features. Vehicle systems have become increasingly complex with the application of various control technologies. Consequently, the increase in the complexity of modern cars also increases the demands on the ability of the vocational field workforce on diagnostics, maintenance and repair. Vehicles will continue to become more complex; therefore, the need for good technicians will continue to grow [1].

As workers creator in the automotive sector, vocational education institutions must be able to ensure the readiness of their graduates to truly master vehicle control technology. In principle, vocational education institutions are the right solution for high unemployment in Indonesia [2]. Vocational education, which is expected to be the right solution to quickly reduce unemployment, is deemed not optimal. This is inseparable from the several weaknesses that still emerge today. One of the weaknesses at this time is that there is a disparity or diversity in the quality of education, especially with regard to skill competencies. In addition, the availability of teaching staff is inadequate in quantity, as well as learning facilities and infrastructure that also do not meet the needs, even 30 percent are left behind 2 generations [3].



Various limitations in the vocational education system in the automotive sector are deemed to still need to be corrected. The development of electronic control systems in vehicles needs to be mastered by diploma level graduates. The problem is, with the complexity of the material, before teaching complex electronic control systems, it is necessary to master the basics of electronic control systems for students. Because, highly effective training program: (1) spell out very clearly what it is and how well students are to learn, (2) provide carefully designed student-centered learning activities to help them get there, and (3) allow each student sufficient time to fully master each task before going on to the next” [4].

So far, basic mastery of electronic control systems in the automotive sector has been developed in the Basic course of electronic control systems, as well as in analog and digital electronics courses. This course studies the basics of automotive control in system input, process and output control systems. However, based on observations, until now the devices or practical facilities used by students in practicum tend to use the basic components installed on the project board. As a result, practicum problems often occur because of the insufficient number of circuit lines. In addition, circuits made on the project board often experience interference due to damaged terminals, or not connected circuitry correctly. Another solution is to practice directly on vehicles with an electronic control system. However, this can create a greater risk associated with safety, difficulty accessing components and high costs [1]. Based on these problems, it is necessary to have a solution to facilitate students in basic practice of electronic control systems that are safe, easy to use and help student learning activities, namely through renewal of practicum facilities. Because, learning facilities affect the school productivity positively and significantly. This indicates school productivity is determined by learning facilities. Therefore, the higher quality of learning facilities, the higher school productivity as well [5]. One of the most important practical tools is practical learning media. The role of learning media in vocational education is very important, because in essence vocational education focuses more on the ability of skills so that it requires learning media that can accommodate knowledge and skill. Development of learning media must pay attention: (a) Pointing the competencies; (b) Pointing learning models to create learning result effectively; (c) Learning media must be designed as the equipment in the real world; (d) Learning media must be made suits with curriculum and learning goals, (e) Learning media must be able to stimulate to improve understanding and skills; (f) Learning media must attract students and easy to use [6].

There are many types of learning media, one of which is educational props. Props help teachers give understanding to students through the embodiment of an understanding [7]. Thus, teaching aids or training kits are needed in practical lectures which are intended to instill abstract technological concepts, such as electronic systems. Instructional media that incorporate concrete experience help students integrate prior experience and thus facilitate learning of abstract concepts [8]. The training kit is expected to support the effectiveness of learning, as the research results show Series and Parallel Circuit Learning Aids shows the effectiveness of electric circuit topics. Appropriateness of teaching aids in teaching and learning to ensure that the content can be delivered and well-received by students [9]. Based on a study of various problems in this learning, this research aims to: (1) the material needed by students in the Basic Practice of Electronic Control Systems in the automotive field, (2) the design of the Basic Electronic Control System Training Kit in the automotive field, (3) the results of the development of the Basic Electronic Control System training kit in the automotive sector, (4) the feasibility of the Basic Electronic Control System training kit in the automotive sector, and (5) the user's response to the results of the development of the Basic Electronic Control System training kit.

2. Method

This study uses a research and development approach. This research was carried out in 5 stages, namely: Analysis phase, Design phase, Development phase, Implementation phase, dan Evaluation phase [10]. The development phases can be seen at figure 1.

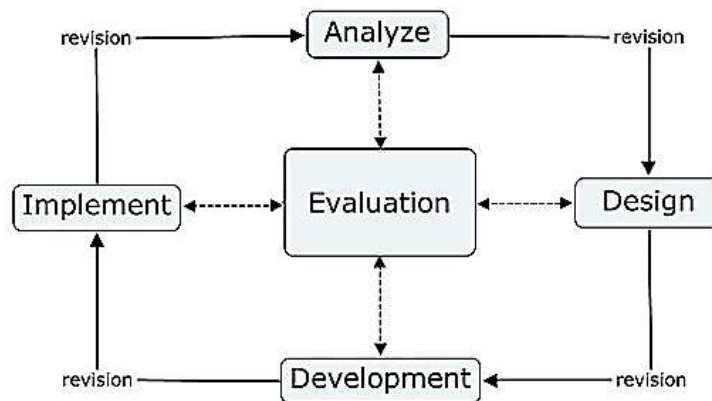


Figure 1. Development step by ADDIE model.

Based on the development step, each step of this study can be explained below:

2.1. Needs Analysis Stage

At this stage, a Focus Group Discussion (FGD) was conducted with lecturers who teach the electronic control system practice in order to map the competency requirements and basic practice materials for automotive electronic control systems.

2.2. Product Design Stage

At this stage, the development of a training kit design is carried out according to input from experts and lecturers.

2.3. Product development

This stage consists of making products according to the design.

2.4. Product Use Implementation

At this stage, student product trials are carried out in the basic practice of Electronic Control Systems.

2.5. Product evaluation

At this stage, an evaluation is carried out based on the opinions and responses of material experts, media experts, and users to determine. To conduct an evaluation, the product eligibility criteria can be seen in Table 1.

Table 1. Product eligibility criteria.

	Score (8 scale)	Eligibility Category
1	1,00–2,75	Very Unworthy
2	2,76–4,50	Not worth
3	4,51–6,25	Well worth
4	6,26–8,00	Very Worth

3. Research Results and Discussion

3.1. Research results

3.1.1. Basic Practice Materials of Electronic Control Systems

The development of learning tools in the form of a basic electronic control system training kit starts from the needs analysis stage. One of the basics of the needs analysis is knowing the material taught on the basic topics of automotive electronic control systems. The basic control system not only recognizes electronic components, but also on the basis of processing the input into an actuation output. Based on observation data, documentation, and interviews with the course instructors, the course material that must be taught in practice can be seen in table 2.

Table 2. Competency arrangement on the basic practice of electronic control systems.

No	Competency	Sub Competency
1	Understand the use of Arduino simulation and programming software	1. Understand the use of simulation software. 2. Able to use the Arduino IDE software to program Arduino
2	Understand the use of functions, looping, and arrays on Arduino 1	1. Using program functions. 2. Using a looping program. 3. Using array programs. 4. Apply functions, looping, and arrays to 7 segments.
3	Understand the use of functions, looping, and arrays on Arduino 2	1. Using a looping program in a loop. 2. Apply multi 7 segment 3. Able to take advantage of the multiplexer process
4	Understand the use of serial communication on Arduino	1. Send data from Arduino to other devices. 2. Receive data from other devices to Arduino. 3. Access bluetooth communication via serial communication on Arduino.
5	Understand the use of 16x2 liquid crystal display (LCD) on Arduino	1. Accessing the 16x2 LCD with Arduino. 2. Displays characters on a 16x2 LCD. 3. Displays characters on 16x2 LCD based on input from Serial.
6	Understand the use of interrupts on Arduino	1. Access interrupt on Arduino. 2. Apply an interrupt to the Arduino. 3. Apply an interrupt timer on Arduino
7	Understand the use of an analog to digital converter (ADC) on Arduino	1. Access the ADC on Arduino. 2. Apply ADC to Arduino
9	Understand the use of infrared sensors on Arduino	1. Accessing passive infrared on Arduino. 2. Apply passive infrared on Arduino. 3. Applies infrared as a proximity sensor on Arduino
10	Understand the use of ultrasonic on Arduino	1. Access ultrasonic on Arduino. 2. Apply the ultrasonic sensor to Arduino. 3. Applying ultrasonic sensor as proximity sensor on Arduino.
11	Understand the use of Pulse width modulation (PWM) on Arduino	1. Access PWM on Arduino. 2. Apply the PWM function to Arduino to control the speed of the DC motor. 3. Apply the PWM function to the Arduino to control the speed of the servo motor.
12	Understand the use of lookup table functions and write data on the Arduino EEPROM	1. Create a lookup table on Arduino. 2. Accessing EEPROM on Arduino.
13	Understand the use of Arduino in automotive applications	1. Program Arduino as ignition control. 2. Program Arduino as injection control.

3.1.2. Product Development Results

After the process of analyzing the needs of the teaching materials, the next step is designing a training kit. The design of this training kit is based on a weakness analysis in the media for previous practical lectures as well as the ideal training kit needs. The results of the training kit design can be seen in Figure 2.

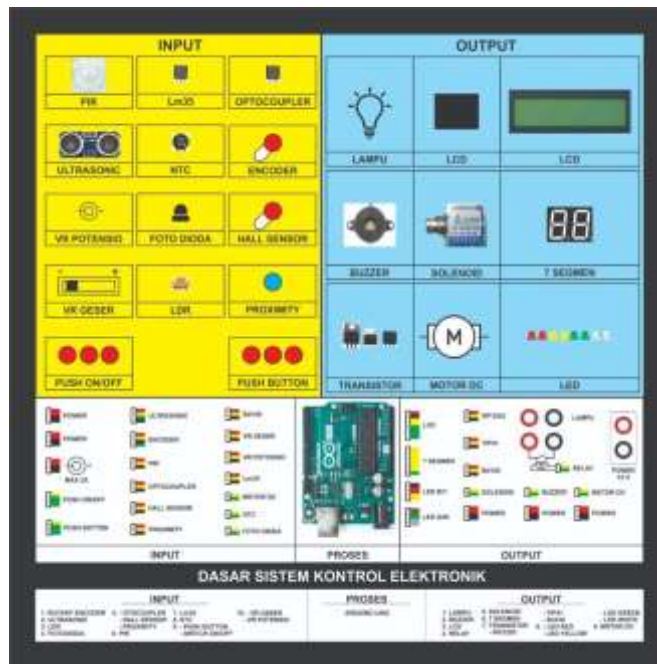


Figure 2. Training kit design.

The designs that are made are then consulted with media experts and material experts to ensure that the products to be made are according to practical needs. after being consulted, there were design changes as illustrated in Figure 3.

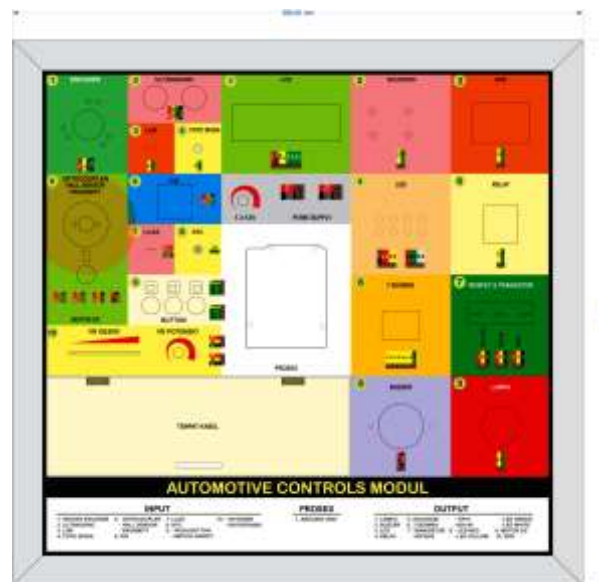


Figure 3. The result of revision of basic training kit design for automotive electronic control system.

After the training kit design is validated, the design is then realized into a real product. The results of the products made can be seen in Figures 4 and 5.



Figure 4. The product results are seen from the top side.



Figure 5. The product results are seen from the side.

Based on the results of the manufacture of the basic training kit product for the electronic control system that was made, it can be seen that the training kit consists of a power supply part, various input components, a process component in the form of an Arduino microcontroller, and various kinds of output and display components. The training kit is packaged in an acrylic box so that it is safe for use with electric currents. The dimensions of the training kit are tailored to the needs of the practice, which supports learning individually or in groups of 2-3 people, besides that, the size also considers storage space.

3.1.3. Feasibility Test Results for Basic Electronic Control System training kit

The basic training kit product for the automotive electronic control system is then assessed for its feasibility by media and material experts. The assessment is seen from the aspects of learning media. The results of the expert's assessment can be seen in the following table.

Table 3. The results of validation by material experts and media experts.

Item	Material expert	Category	Media expert	Category
Mean	7,47	Very worthy	7,56	Very worthy
Minimum score	3		7	
Maximum score	8		8	

In addition to the results of the assessment of product feasibility, input and suggestions from experts were also obtained, which can be summarized in table 4.

Table 4. Expert suggestions

Expert suggestions	Revision action
It is very feasible to be used in learning	No revisions
It is necessary to add sensor components that show the development of automotive electricity.	Given an additional complete sensor
There needs to be a model for using sensors or actuators in vehicles.	There is no revision, because the usage model will be continued on the jobsheet
The electronic control circuit requires adjustment to automotive standard components	Adjustment of components, cables and connectors
The training kit module is very supportive of lectures in the process of identifying the types of input and output, process systems, and basic programming.	No revisions

Based on the results of the feasibility assessment by material experts and media experts, it can be seen that the product developed can be said to be suitable for use. This can be seen from the feasibility average score obtained by a score of 7.47 and 7.56 from a scale of 8. In addition, from the results of expert input, only minor revisions were made. Thus, the developed training kit can be used for basic lectures on electronic control systems as well as analog and digital automotive electronics.

3.1.4. User responses to the product being developed

After the developed training kit is said to be suitable for use, the user is asked to respond to the training kit. User respondents are students of Automotive Engineering Education, Faculty of Engineering, Yogyakarta State University. The selected students are those who have attended basic lectures on analog and digital electronic and electronic control systems. Student responses to the developed training kit can be seen quantitatively in table 5.

Table 5. The results of student responses to the developed training kit.

Aspect	Maximum score	Minimum score	Mean	% Achievement	Category
Display	8	3	6,85	85,7%	Very good
Accessibility	8	3	6,83	85,4%	Very good
Motivation	8	4	7,08	88,5%	Very good
Benefit	8	4	7,28	91,0%	Very good
Mean			7,02	87,7%	

Based on table 5, it can be seen that overall, students from these aspects of learning media, it can be seen that the training kit has a very good appearance, easy access, supports learning motivation, and is useful for students. However, seen from the lowest score in all aspects, there are scores of 3 and 4. From the results of the student response analysis, the lowest score from the display aspect is the appearance of the component symbols, but this is natural because the training kit does not include component symbols. In the aspect of ease of access, there is a low score (3), which is the item on the use of costs in utilizing the training kit. In the aspect of motivation, there is one answer that gets a value of 4, namely the desire to learn further. In the aspect of benefit, there was one participant who filled in the value 4 on the desire to create new things. In addition to responses to predetermined aspects, students provide some suggestions and input on the training kit being developed, as a summary below: (a) more training kits need to be made because they are very useful; (b) it is need additional instructions for use and (c) it should use components that are easy to find replacements in case of damage.

3.2. Discussion

Learning electronic control systems in the automotive engine, automotive chassis, and other parts must be based on various abilities that train students to master the working concepts of electronic control systems. Learning is very much influenced by the means and media of learning. However, to understand the technology applied to the automotive electronic control system, it is necessary to master the basic capabilities of the automotive electronic control system. By mastering the basics, learning the application of automotive electronic control systems will be easier to implement. Based on the research results, there are many basic competency requirements for automotive electronic control systems that students must master, such as recognizing the basic components of control, namely the power, input, process, and output components; basic programming; as well as management / manipulation of electronic control systems.

Based on the results of training kit development, a training kit that meets the feasibility aspects is obtained. In terms of appearance, ease of access, perception of motivation, and benefits got good results. This can be seen from the assessments of learning experts and material experts about automotive electronic control systems. Judging from the student response, the training kit has been declared very good as shown in Figure 6.

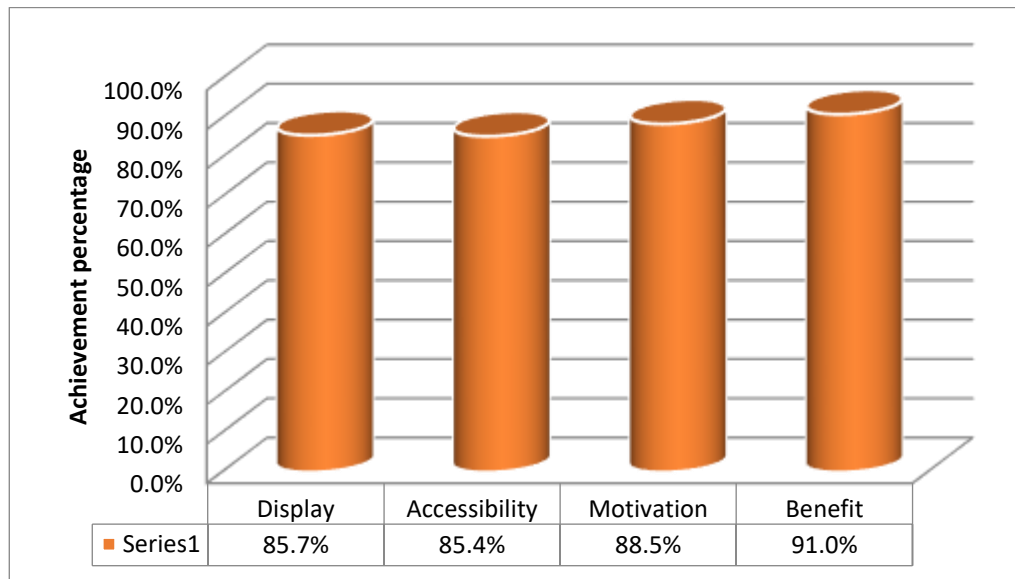


Figure 6. Results of student responses to the eligibility of the training kit.

Basic training kits for automotive electronic control systems as part of practical learning tools are very much needed by students. With a training kit that contains the basic components of electronic control systems, basic programming of control systems, and manipulation of electronic control in the automotive field, it can encourage student motivation and the effectiveness of practical lectures. This is in line with what was conveyed by Kob, C. G. C., Abdullah, A. S., Norizan, N. A. A., & Shamsuddin, H. (2019) that: Practical training using this learning aid helps to improve student performance. Learning aid also creates the interest and motivation of students in teaching and learning because it is easy to understand as compared to traditional learning [9]. Through the use of training kits, trainees can enhance the theoretical knowledge and hands-on skills aspects [11]. Thus, students who master the basics of automotive electronic control systems will be able to understand more quickly the electronic control systems in vehicles.

4. Conclusions

Based on the analysis of research data and discussion that has been done, it can be concluded that: (a) materials needed by students in the basic practice of automotive electronic control systems include: understanding the use of simulation software, functions, arrays and looping on Arduino, serial communication, LCD use, use of interrupts, use of analog to digital converters, infrared sensors, ultrasonic sensors, pulses width modulation, lookup table function and EEPROM data writing, and Arduino applications in the automotive sector; (b) basic training kit development products for automotive electronic control systems developed in the form of educational displays containing parts of the power supply system, various variations of input, process systems with Arduino Uno, and output parts in the form of lights, buzzers, electric motors, solenoids, 7 segment displays, LCD, relay, and driver transistor. The model is packaged in a box for individual and group learning of 2-3 people; (c) the developed training kit was deemed very feasible according to media experts and automotive electronic control system material experts. Judging from the average score of the material aspects and media aspects in the category it is very feasible to use and (d) the developed training kit received a positive response from the selected student sample. Judging from the average score obtained, the grades are very good in gradations.

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