Development of cooperative learning based electric circuit kit trainer for basic electrical and electronics practice

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Abstract. This study aims to develop an electric circuit trainer kit learning media, study the feasibility of trainer kit learning media, study the feasibility of worksheets for electric circuit learning media, and determine the effectiveness of electric circuit learning media. This study refers to the ADDIE model (Analyze, Design, Development, Implementation, Evaluation). The results showed that the learning media feasibility of the electric Circuit trainer kit-based cooperative learning was included in the category very decent with an average score of 102. Job sheet Media learning is in a very decent category, with an average score of 93.5. Electric circuit trainer-based Cooperative learning is rated very useful for basic electrical and electronics practice with an average n-gain score of 0.77.

1. Introduction

Cooperative learning involves not only communications between teachers and students, but also the interaction between teachers in the learning model, the use of learning methods, and effective use of learning media [1]. Learning itself is complex, and many factors influence it, and learning is demanded by the learning model that encourages students to learn there are variations in learning [2].

With the rapid development of the electronics industry, the vocational program of electrical engineering expertise has passed the learning media that support the learning process. Like the basis of electricity and electronics, which is one of the subjects that must be studied by students in the electrical vocational skills program. For teachers, it is easy to explain the material to be conveyed. For students, they understand and understand the material of ohm law, Kirchoff's law, series, parallel circuits, and AC circuits in practical basic electrical and electronic subjects. Students to discuss material about electricity at the qualitative level are difficult conceptual challenges. Concepts, such as voltage, current, and resistance, are intangible and abstract and difficult to solve [3]. The kit trainer is a set of equipment in the laboratory that is used as an educational medium. The kit trainer will be developed due to absence from school. It is hoped that by using this kit trainer, students can apply knowledge material/concepts to practice so that the abstractness of knowledge and verbality can be reduced. Besides, it is also because

trainers are media that can be seen and have a 3-dimensional form that is expected to attract attention and increase student motivation [4].

The kit trainers that will be developed include active components and passive components equipped with measuring devices and made more flexible in their use, such as a blackboard frame with wheels to make it easy to move. The learning media in the form of trainer kits can be used in the learning process to increase desire and interest in learning, arouse motivation, and stimulation of learning activities and even influence towards students' psychology. [5].

Students who tend to lack understanding of material are very dominant. Most students assume that learning theory is less able to be absorbed and understood; students more readily accept the lessons that are practiced, where students know the application of lessons in practical activities [6]. Its means that learning media is needed; it can be proven by the presentation of the value of students who only reach the KKM limit of 75 out of 70% of students in one class. The level of success of learning can be said to be lacking if the learning material that has been delivered is less 75% mastered by students [7]. This means that the level of success of learning in Vocational High School No. 2 Serang can be said to be lacking with the presentation of only 70% students and lack of effectiveness of students in practical learning because the teacher only relies on the application as a simulation to replace the electrical circuit learning.

Based on the description above, we are interested in making a learning media that can be used as an electric circuit trainer in which there are ohm law material, Kirchoff law, series, parallel circuits, Wheatstone bridges, and AC circuits equipped with measuring instruments. This trainer is packaged in the form of a rectangle measuring 42 cm x 29.7 cm and made a skeleton-like a whiteboard according to the size of the trainer with a 5mm acrylic base material. The benefits of learning media clarify the delivery of material learning messages so that they can increase student attention and interaction and can equate student perceptions. Besides that, the benefits of learning media can facilitate teachers in delivering learning material, but how much the benefits of learning media will not be able to replace the teacher completely [8]. The kit trainer is a collection of actual components or tools or duplicates of the actual ones that can provide direct experience for students. Media objects, namely objects, models or real objects that are very similar to objects will provide essential stimuli for students in learning assignments and concerning psychomotor skills [9].

Some learning media that has been developed for the learning of electric circuits include computer-based PowerPoint presentations, whiteboards and a combination of handouts and whiteboards [10] that show presentation media Computer-based PowerPoint and a combination of better than just using a whiteboard in impacting student learning. Also, [11] mentions that learning the practice of electric circuits is better if done comprehensively, namely a combination of virtual and physical laboratories. Modules or tools of practice that have been developed include a robot line following automatically [12], Mechatronics Learning Module [13], and embedded system laboratory kit [14], [15].

In this digital age, technology should be a critical enabling factor and students expect its adoption to support the learning process [16], so it appears various kinds of e-learning [17] but [18], stated that computer-based learning by utilizing the computer is as effective as laboratory-based learning on the achievement of student learning outcomes. In the study of laboratory-based practices, there has been many who developed trainer kits for practice activities, especially on basic electronic and electrical subjects, therefore, need to be developed electric circuit kit trainer-based Cooperative Learning for the practicum of basic electrical electronics.

The urgency of this research is so that students easily understand the basic electrical and electronic subject matter. The lack of facilities for learning aids provided by schools is one of the triggers for students' low interest in learning, especially in the face of the practicum program. The basic electrical and electronics practice is the basis of learning that is applied in the industrial world, becoming one of the teaching materials for students majoring in order to develop to meet the demands of the industrial world [19], [20], [21].

2. Method

Research and development procedures are used in this study. This research was adapted from [22], [23], [24] covering 5 stages: (1) Analyze, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. This research was conducted from January to February 2019 at Vocational High School No. 2, Serang City, Banten. The subject of product validation is by four material experts and three media experts. The subject of the testing of instructional media products and electric circuit job sheets in this development research was the tenth-grade students of electrical engineering at Vocational High School No. 2, Serang City. Subjects of this development study are XTL 2 graders in vocational high school No. 2 of Serang City in the Department of Electrical Engineering that takes the basic electrical and electronic subjects as many as 30 students.

2.1. Research procedure

The research method for developing learning media is the development research method, known as Research and Development (R & D). This research aims not to produce new theories or test existing theories but to develop existing products that can be useful for their goals [25]. In this development study using ADDIE models. Research and development using ADDIE models because these models are arranged programmatically with sequences of systematic activities in efforts to solve learning problems related to learning resources that are following the needs and characteristics of students. The ADDIE model provides opportunities at each stage of evaluation, the purpose of which is to minimize the level of product error in the final stage. The ADDIE model consists of five stages, namely: (1) Analyze, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. The five stages of the development procedure above can be seen in Figure 1. [22]

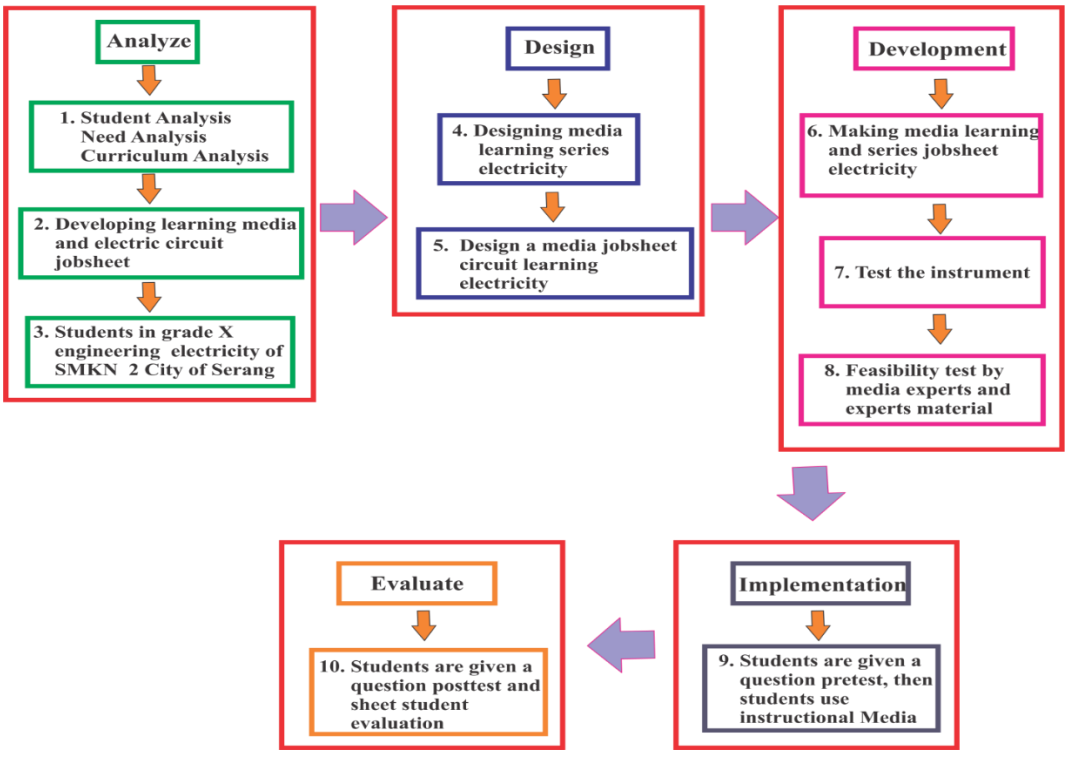

Figure 1. Development procedure after being reduced

3. Results and discussion

Based on the research that has been carried out in the form of the development of electrical circuit trainer kit learning media, the following results are obtained:

3.1 Learning media development

The first stage is to analyze. The first step to finding out the condition of the school researchers carries out learning through the learning process. The analysis carried out was student analysis, curriculum analysis, and needs analysis. The following table of basic competencies to be developed in an electric circuit trainer can be seen in Table 1.

Table 1. Basic competencies in Basic Electrical and Electronics subjects

Basic Competencies	Subject Matter
Analyzing Direct Current Electric Circuits	- Ohm's law - Kirchoff's Law - Series of series - parallel circuit - AC circuit - Wheatstone Bridge

The second stage designs. Design made using Corel Draw X8 application. The electric circuit trainer is made using a framework such as a blackboard and equipped with each leg using wheels so that it can be easily moved. The top of the trainer is a measuring instrument and an incandescent lamp as an AC circuit output. The bottom of the trainer is an example of active and passive electronic components. The design that will be developed can be seen in Figure 2 and Figure 3. The design is made as attractive as possible to make a trainer equate the same understanding for students about an original object so that in the end learning outcomes that exceed the average class score are also achieved success from the curriculum. [26]

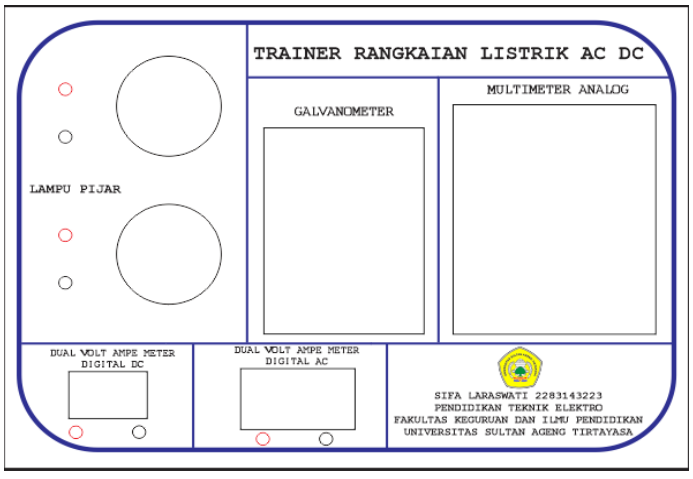

Figure 2. Hardware design of the upper electrical circuit trainer

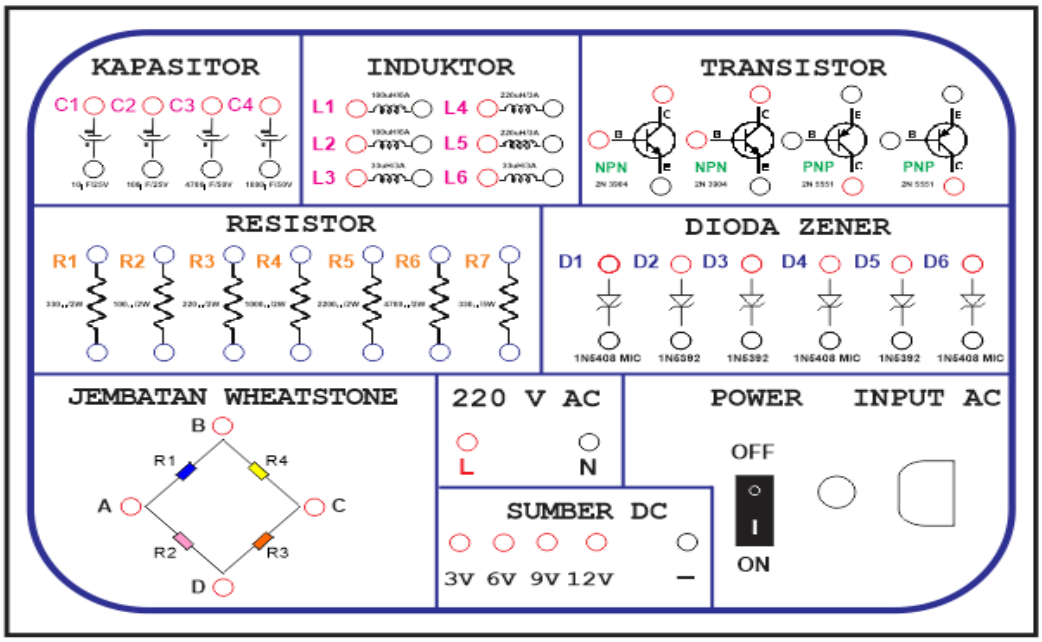

Figure 3. Hardware design of the lower electrical circuit trainer

The third stage is the development. This study develops learning media for electrical circuits in the form of electric circuit trainers and creates worksheets to be used as guidelines in using electric circuit trainer learning media. After becoming the media before carrying out the research, the media and material expert validator will be assessed. The development of learning media created can be seen in Figure 4.

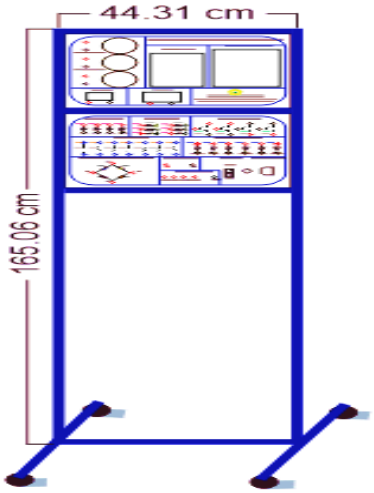

Figure 4. Hardware design of electric circuit trainer (front view)

The fourth stage is implementation. The implementation phase was carried out when learning media and job sheets were validated, revised, and also approved by media experts and material experts. The

problem-solving skills that exist in the class can be improved through teaching aids that are in accordance with the courses taken [27].

The fifth stage of evaluation. This evaluation phase is the stage where the researcher looks at the improvement of students' abilities when they have used the electrical circuit learning media along with the job sheet. The next student worked on the post-test questions as many as 20 multiple choice questions and five description questions in 45 minutes.

3.2. Feasibility of learning and job sheet media judging from material experts and media experts

The level of feasibility of this learning media can be seen from the results of material experts and media experts based on the assessment of content validity, construct validation, and constraint validation using the following results:

3.2.1. Material assessment

The assessment of the electric circuit learning job sheet by material experts came from two material expert lecturers and two teachers in the electrical engineering department. Assessment aspects of material experts based on educational aspects. The media expert assessment score can be seen in Table 2.

Table 2. Results of material expert validation

Number	Respondents	Educational aspects	total	results
1.	Material Expert 1	90	90	Very Effective
2.	Material Expert 2	100	100	Very Effective
3.	Material Expert 3	86	86	Very Effective
4.	Material Expert 4	98	98	Very Effective
	Average Score		93,5	Very Effective

Based on the data obtained in Table 2, the feasibility category was obtained by material experts from the educative aspect with the number of score of material experts 1 amounting to 90, the number of score scores from the material expert 2 amounting to 100, the number of score scores from material experts 3 at 86, and the number of score scores of material experts 4 is 98. The results of the number of scores from 4 material experts then obtained a mean score to determine the feasibility of material experts with a result of 93.5. The score from the material expert validation can be seen in Figure 5.

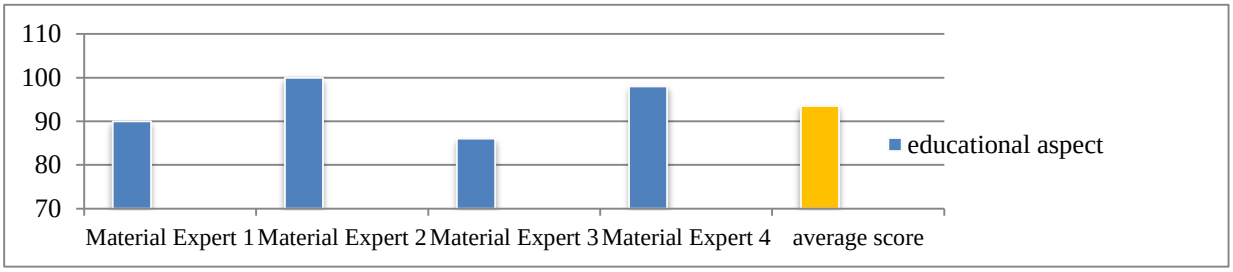

Figure 5. Score from the material expert validation

The average assessment results of the four experts in the learning material are 93.5. So that it can be seen in the range table the score of 93.5 is in the interval $x \geq 75$, which means it is in the "Very feasible"

category. In that sense, this electrical circuit learning media from all aspects of the material is very feasible to use for practical learning of students in the class.

3.3. Evaluation of media experts

The assessment of electric circuit learning media by media experts came from two media expert lecturers and one teacher in the electrical engineering department. Assessment aspects for media experts are based on technical aspects and aesthetic aspects. The media expert assessment score can be seen in Table 3.

Table 3. Results of media expert validation

Number	Respondents	Technical aspects	Aesthetic aspects	total	results
1.	Media Expert 1	49	49	98	Very Effective
2.	Media Expert 2	55	58	113	Very Effective
3.	Media Expert 3	50	45	95	Very Effective
		Average Score		102	Very Effective

Based on data obtained in table 3, the feasibility category obtained by media experts from technical aspects and aesthetic aspects with the number of the score of media experts 1 is 98, the number of the score of media experts 2 is 113, and the number of score scores of media experts 3 amounting to 95. The results of the number of values from 3 media experts then obtained a mean score to determine the feasibility of media experts with a result of 102. The score from the media expert validation can be seen in Figure 6.

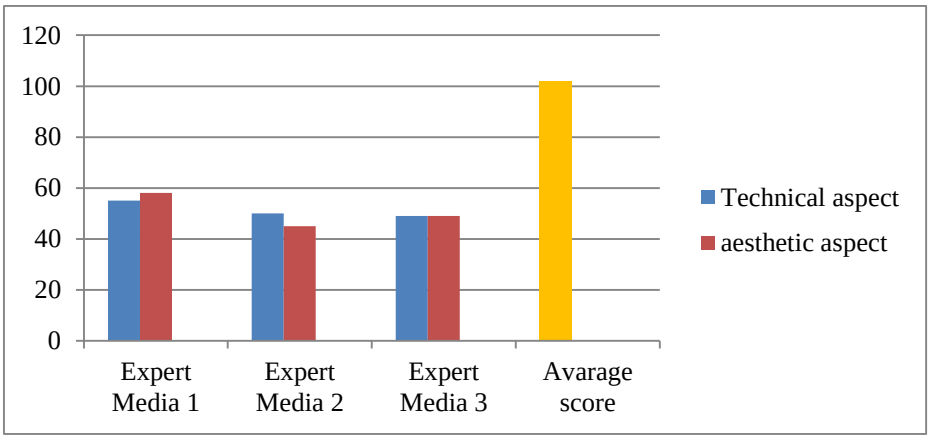

Figure 6. Score of media expert validation results

The average assessment results of the three learning media experts are 102. So that it can be seen in the range table the score of 102 is in the interval $x \geq 90$, which means it is in the very feasible category. In that sense, this electrical circuit learning media from all aspects, both technical aspects and aesthetic aspects, is very suitable to be used for practical learning of students in the class.

3.4. The level of effectiveness of learning media and learning jobsheets

The level of effectiveness of the electric circuit learning media can be measured using student learning outcomes in the form of the pre-test and the post-test. The learning media and the electric circuit job sheet are said to be effective if the majority of students get better results than before, and are said to be

less effective if there is no increase in the assessment results in student learning outcomes. The following are the results of tests that have been carried out can be seen in Figure 7.

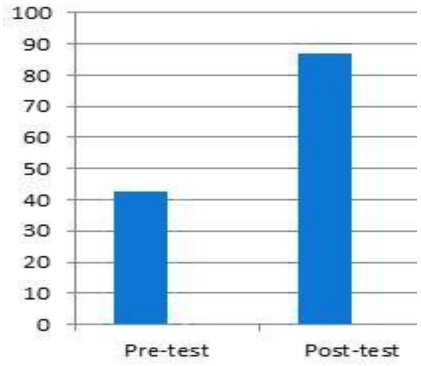

Figure 7. Comparison of pre-test and post-test values

The research subjects were class XTL 2 students at Vocational High School No.2 Serang City, amounting to 30 students. Pre-test and post-test that have been carried out produce data that can be seen in Figure 7. Comparison of student learning outcomes before and after using learning media has significantly increased the results. [28].

The average result of the pre-test score is 42.53, while the average post-test value is 87.06. If the results of this test are calculated using the n-gain formula to determine the effectiveness of the electric circuit learning media, a score of 0.77 is obtained. If you see from Table 4, the interpretation categories are stated to have very high effectiveness.

Table 4. Effectiveness of electric circuit kit trainer learning media

Score average	Category
0. 77	Very high

The student evaluation sheet is carried out by giving students a questionnaire that aims to find out suggestions and additional input from users. In this evaluation sheet, use the Likert scale 1-4. The average score obtained is 94.03 in the category of very feasible. Suggestions and input that many receive is to increase the number of trainers, increase the size of the trainer, trainers are easy to use so as to make students understand more about the material. Suggestions and inputs are what can be used to continue the development of learning media. The results can be seen in Table 5.

Table 5. The results of the feasibility test of learning media in students

Score average	Category
94.03	Very feasible

The overall results of each evaluation obtained an average percentage of 91%. Based on the test data obtained the effectiveness of learning media data is 91%, according to the Rating Scale on [29] this learning media is categorized very well which means that the use of instructor trainers and job sheet media can be categorized as effective in learning. The effectiveness test of the electrical Circuit kit trainer gained a percentage of 91%. So, trainers and jobsheet are categorized very effectively to be used

as a means of learning practical subjects of basic electrical and electronics. The Trainer kit is also equipped with a practical jobsheet that encourages students to participate actively and cooperate in the process of practicum.

4. Conclusion

Based on the results of the research and the results of the development of the electric circuit learning media along with the lab worksheet, it can be concluded as follows: learning media products in the form of trainers and job sheets for electrical circuits. The level of feasibility of the electrical circuit learning media gets a score of 102 which is in the category of very feasible. The feasibility level of the electric circuit learning jobsheet gets a score of 93.5 which is in the category of very feasible. The level of effectiveness of the trainer learning media and the electric circuit jobsheet is very significant. The results of the average assessment of students showed a value of 42.53 before using learning media and electric circuit jobsheet and a value of 87.06 after using learning media and electric circuit job sheets.

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