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Development of RLC Teaching Aids as Learning Media for Alternating Voltage Circuits to Improve Student Learning Outcomes

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Abstract

Learning media is a tool to facilitate the delivery of learning materials. Unfortunately, learning media, especially in Physics, was found to be lacking at the secondary school level. This study aims to develop appropriate teaching aids with valid, practical, and effective criteria for improving student physics learning outcomes. This research is an R&D (Research and Development) research with the ADDIE model (Analyze, Design, Develop, Implement, and Evaluation). The validity of the teaching aids is determined based on the validation results of three expert validators, and the student's response determines the practicality of the teaching aids after learning. The effectiveness of teaching aids is determined based on student learning outcomes in the aspect of knowledge. The study used a one-group pretest-posttest design with 29 grade XII students of SMA Tamansiswa Mojokerto as the subject. The results showed that the RLC series of teaching aids developed (1) were categorized as very valid, (2) students gave a positive response to the use of RLC teaching aids, and (3) student learning outcomes were stated to have increased in the moderate category. Based on the study results, it can be concluded that the RLC teaching aids that were developed are feasible (valid, practical, and effective) to be used as learning media to improve the learning outcomes of class XII students of SMA Tamansiswa Mojokerto.

Keywords: teaching aids, alternating current electricity, learning media, RLC circuit

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INTRODUCTION

Technological developments indirectly affect the world of education. Education is gradually undergoing improvement and renewal with various creative and innovative breakthroughs to improve the quality of education in Indonesia. Changes in concepts and learning methods that are entirely centered on students (Masyruhan et al., 2020), are one example of reforming the teaching and learning process. Minister of Education and Culture Regulation number 22 of 2016 states that schools must create interactive, inspiring, fun, and challenging activities to motivate students to take part in learning. In this case, where previously, the teacher who acted as the sole learning resource (teacher center) changed to students who were active in learning (student center) (Kahar, 2017).

Learning activities become meaningful for students if they are actively and attractively involved. Based on 3M's mission, namely observing, studying, and utilizing various natural phenomena in their environment (Ramadhan & Hasyim, 2019). Students are guided to master the ability to observe and experiment to practice thinking skills and scientific work (Hartati, 2010). Furthermore, one of the branches of science under these provisions is physics. In contrast to the actual reality, learning physics is considered by some students to be challenging to understand, so its attractiveness begins to decline. Several factors are causing it, one of which is the lack of motivation to learn, and students are still passive in learning activities, especially physics. One of the causes is the use of learning media that is not in accordance with the situation in the classroom (Purwanto & Hendri, 2016).

Learning media is essential and acts as a communication tool to make the classroom atmosphere engaging and effective (Adi, 2017). Given the growing digital era, creativity in the preparation of learning media should be improved. A teacher must think innovatively and creatively to determine the suitable media adapted to the classroom situation. Therefore, we need media that can clarify the presentation of the theory given by the teacher to students. In this case, the right learning media is needed to understand concepts, primarily abstract physics material, namely teaching aids (Kause, 2019).

The limitation of physics teaching aids in schools is one of the factors that cause learning to be less than optimal, especially in physics lessons (Qomariyah et al., 2020). These obstacles can be optimized using visual aids that visualize material or concepts that are difficult to see directly by the eye or the need for deep understanding so that it takes a long time (Maharani et al., 2017). The school has provided teaching aids as learning support, but they are limited and only used for certain teaching materials (Novia, 2018). Students will gain direct experience during practical activities using teaching aids (Cahyono, 2017). These experiences make students place new concepts into their long-distance memory systems, so with these experiences, students have higher levels of thinking. With that, props are needed with abstract material that students have not previously found in their learning (Marscella et al., 2019) .

The material given is abstract and cannot be seen directly, namely a series of alternating currents and voltages or can be abbreviated as AC (*Alternating Current*). The AC circuit material is taught in the odd semester of class XII. Contextually, this material is closely related to everyday life. This material studies the magnitude of the current and voltage values flow in an alternating circuit. Furthermore, what about the value of alternating current and voltage when flowing into a circuit composed of resistors, inductors, and capacitors, commonly known as an RLC circuit. To show the process of flowing current and voltage in alternating circuits or RLC circuits, a medium is needed to explain these problems (Wulantri & Ali, 2018).

A learning activity needs to be assessed every time the learning process is carried out. The assessment determines student achievement in learning objectives (Rufaidah, 2019). The results assessed cover several aspects of learning, including the knowledge aspect. Various tests are carried out to fulfill the knowledge aspect assessment, such as written tests, oral tests, and even assignments. The assessment results of knowledge achievement are reported in 3 forms: numbers (0 to 100), predicates (A, B, etc.), and descriptions. The education unit determines the rendang assessment interval by considering the Minimum Completeness Criteria (Jiniarti et al., 2015).

Based on this description, this study aimed to develop an appropriate RLC circuit teaching aid with valid, practical, and effective criteria for improving students' physics learning outcomes on alternating current and voltage circuit material. The formulation of the problem posed in this study is (1) how is the validity of the RLC circuit teaching aid?, (2) how is the effectiveness of the RLC circuit teaching aid based on student learning outcomes, and (3) how is the practicality of the RLC circuit teaching aid obtained from the student's response at the end learning.

METHOD

This type of research is research and development, or R&D (Research and Development), a method that can produce and test the effectiveness of products such as AC circuit props. Furthermore, the procedure used in this study is the ADDIE model, which stands for (*Analyze, Design, Develop, Implement,* and *Evaluation*) (Octaviana, 2017).

The analysis stage is carried out by observing field conditions to determine the problems that occur in students (Rosdianto et al., 2019). Then in the *design stage*, the initial design of teaching aids is carried out, and the selection of materials then designs the teaching aids based on the competence of learning in class. Suppose the tool's design has been completed. In that case, it enters the development stage, which is producing a *prototype* of the AC circuit props and then being validated by certain parties (*Siwardani* et al., 2015)—i*mplementing* or applying teaching aids in learning to test their validity and effectiveness. Furthermore, the last stage, namely *evaluation,* serves to measure the feasibility of using AC circuit props seen from three test aspects, namely: validity, tool effectiveness, and practicality of the tool (Desy et al., 2015).

Figure 1. Research using the ADDIE model (Kurt, 2018)

The design of this study used *one group pre-test-post-test*, which was an initial test before the research started and a final test after the research was carried out. This research is limited in nature, where the research subjects consist of 29 grade XII students at SMA Tamansiswa Mojokerto. The research subjects came from three different classes with the same academic ability.

The research product in the form of teaching aids was tested with three aspects of assessment, namely the validation of the teaching aids, the practicality of the teaching aids, and the effectiveness of the teaching aids. Furthermore, for data collection, research was carried out by three different methods: observation, tests, and questionnaires. Here the aspects of the assessment are mutually sustainable with the data collection method. Each method is equipped with different research instruments (HD Saputro, 2020). First, the observation is divided into two stages, and namely, in the pre-research and during the experimental activities, the researcher will assess the compatibility between the devices that have been prepared with the implementation of experimental learning. Second, the test method is tested to determine the value of the aspects of intelligence, knowledge, skills, and abilities of each individual. The intended test is the initial learning test, namely the *pre-test* and the end of the *post-test learning*, the test is in the form of multiple-choice questions which are carried out individually. In addition, the Student Worksheet was also tested, which was carried out in groups of 4 to 5 people during the experimental activity, the test contained the concept of the RLC series as well as the steps of the experimental activity that students had to obey to get the relevant results (Khasanah & Sunarti, 2016) . Previously, the student worksheets had been adjusted to the competency indicators for alternating current circuit material. Third, the questionnaire method was used to determine or measure student responses to alternating current circuit learning based on experimental activities assisted by RLC teaching aids carried out by researchers in the three classes. Previously, the validation of media and materials in the form of RLC series props had been carried out by two expert lecturers (VC Saputro, 2019).

The RLC series of teaching aids is validated by a lecturer who validates an assessment instrument by marking each criterion according to the state of the teaching aid. There are three validators involved in this study. The validator criteria needed in this study are lecturers majoring in physics education and mastering magnetic electricity (Wahyuningsih et al., 2019). The instrument used a rating scale with the highest value of 5 and the lowest value of 1. It can be said whether a teaching aid is valid or not, judging by the compatibility of the validation results by the lecturer with the range of criteria in table 1,

Table 1. Props Validation Criteria

Average Value of 3 Validators	Rating Category	Rating Description
0% - 20%	Invalid	Cannot be used
21% - 40%	Not valid	revision needed
41% - 60%	Quite valid	It is recommended not to use, a large revision is required
61% - 80%	Valid	Usable but requires minor revision
81% - 100%	Very valid	It can be used without revision

The practical aspect can be seen in the students' responses to the questionnaire before the end of the lesson. The questionnaire sheet also uses a questionnaire sheet distributed using an online platform so that students only choose from the four available options. Of the ten questions presented, all students' answers will be averaged and analyzed so that the percentage value of each question is obtained (Damayanti et al., 2022). To calculate the percentage of respondents' answers, the following formula is used:

$$\% \text{ Response} = \frac{\text{Score obtained}}{\text{Total Score}} x\ 100\% \qquad (1)$$

And to determine the percentage of responses given by students during learning, the formula is used:

$$\text{percentage} = \frac{\text{Score obtained}}{\text{Total Score}} x\ 100\% \ (2)$$

(Arikunto, 2010)

Then to determine the percentage of responses from students, using the criteria for the percentage of student response scores in table 2 as follows,

Table 2. Criteria for the percentage of student response scores (Riduwan, 2010)

Average Score	Criteria	Information
0% - 20%	Not good	Not practical
21% - 40%	Not good	Less practical
41% - 60%	Enough	Less practical
61% - 80%	Well	Practical
81% - 100%	Very good	Very practical

The effectiveness of teaching aids is measured by student learning outcomes, which are given at the time of learning. Assessment of student learning outcomes seen from the aspect of knowledge. Learning outcomes from the knowledge aspect were observed with a test instrument in the form of 10 questions in the form of multiple-choice (Melati, 2018). So to find out the increase in students' cognitive learning outcomes, it is calculated using the n-gain test formula as follows,

$$< g >= \frac{(\text{pretest score}) - (\text{posttest score})}{\max score - (\text{pretest score})} \quad (3)$$

Furthermore, the calculation results are categorized according to the following table 3 gain categories,

Table 3. Rating category *n-gain*

Score Gain	Category
$(\langle g \rangle) < 0.3$	Improving learning outcomes is low
$0.3 < (\langle g \rangle) < 0.7$	Moderate improvement in learning outcomes
$(\langle g \rangle) > 0.7$	Improved high learning outcomes

Meanwhile, aspects of skills are used to support the assessment. Skill assessment is obtained from observations when students carry out experimental activities, such as assembling experimental tools and materials or student steps in obtaining experimental data (Lorenza et al., 2019).

RESULTS AND DISCUSSION

Analyze

This stage serves to determine the problems faced by students in classroom learning. Based on the observations of researchers in class XII MIPA, they totaled 29 people and the results of interviews with the physics tutor. Previously, researchers had carried out PLP activities (Introduction to School Fields) in that class so that they could provide views on some of the problems of students when learning activities took place in class.

Based on the observation of the problem of class XII MIPA students, namely the lack of understanding of the concept of dynamic electricity, this is evidenced by the scores that do not meet the KKM. One of the reasons is the absence of experimental activities that can support the achievement of these competencies. From several sub-subjects of dynamic electricity, the sub-chapter of alternating voltage electricity (Alternating Current) in series RLC circuits requires particular emphasis (Rochaeni, 2015). Due to the lack of experimental tools to support the material, students carry out KBM without direct evidence. Therefore, we need an experimental tool kit for alternating voltage or AC electricity that focuses on RLC circuits in series (Haryadi et al., 2019).

Design

The design stage begins with designing the initial design of the AC power kit on the RLC circuit, called APRa-RLC or an abbreviation of RLC circuit props. Previously, the design of this circuit was inspired by student books, so the researchers adapted it into a teaching aid that later students could directly observe the nature of the alternating electric voltage in the RLC circuit (Aji et al., 2017). The following is an illustration of the first design of the kit adapted from the student book as shown in Figure 2 below.

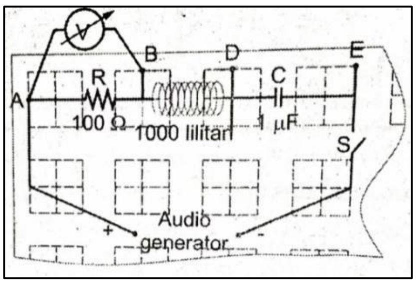

Figure 2. The initial design of the RLC circuit prop kit (MGMP, 2018)

From this design, the researchers redeveloped it with materials that are easy to find, lightweight, and practical so that the storage of teaching aids will be flexible. The circuit board is designed as shown below, then printed using sticker paper and affixed to a board made of acrylic.

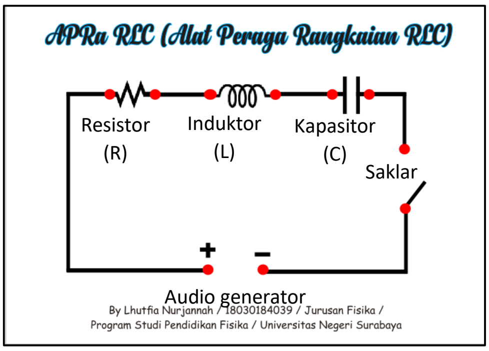

Figure 3. RLC circuit board adaptation design.

Next, the circuit board will be assembled using several electronic components. Where the circuit board is composed of; (1) electronic components such as resistors, inductors, and capacitors, (2) knife switches, (3) connecting cables, and (4) alligator clips. In addition, other electronic devices such as audio frequency generators are also needed to determine the amount of frequency used.

So that the framework of the RLC circuit *prototype kit was created.* In addition, the researcher also prepared a set of lessons, including the Learning Implementation Plan, alternating current and voltage electric handouts, Student Worksheets, student assessment sheets, question grids, and student questionnaire sheets (which contained student responses during the learning process). with props) (Beautiful, 2014) . The results of the *prototype* framework and learning tools were then reviewed and validated by three expert lecturers in the following figure,

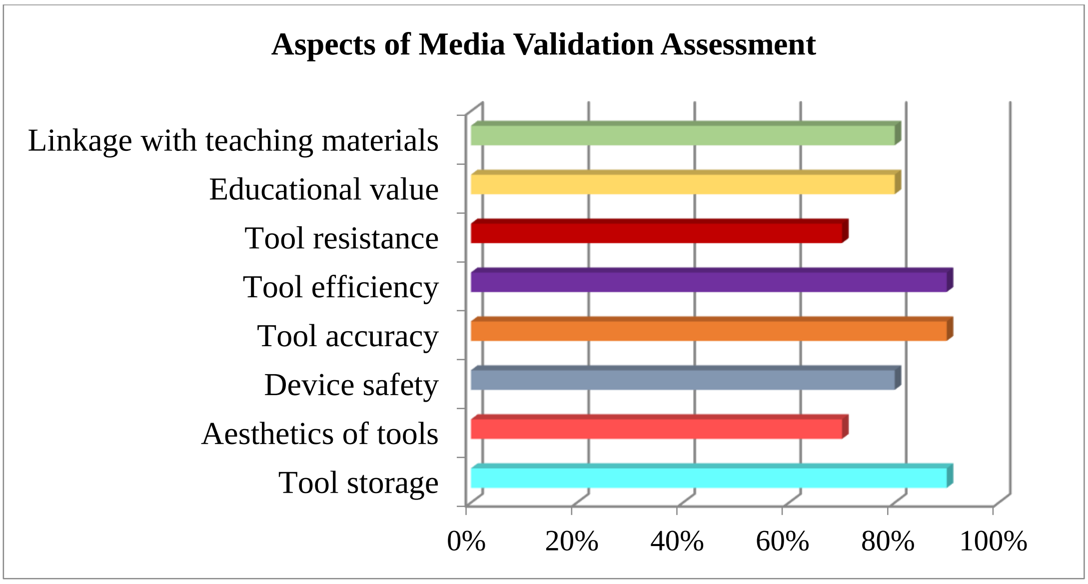

Figure 4. Media validation result recapitulation graph

The media validation data processing shown in Figure 4 shows that the three aspects of the assessment that have the highest percentage, respectively, are the efficiency of the teaching aids, the accuracy of the tools, and the storage of the tools with a percentage of 90%. Furthermore, there is also an assessment aspect with the lowest percentage, namely tool resistance and tool safety with 70%. These results are since teaching aids are composed of electronic components that need good handling following the procedures for storing tools, and their use must be accompanied by experts (Setyowati & Sucahyo, 2020).

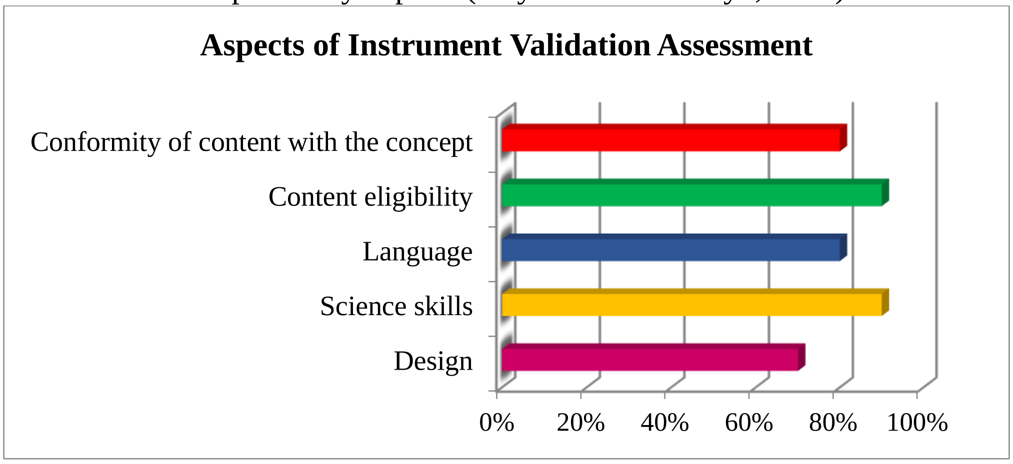

Figure 5. Graph of recapitulation of instrument validation results

Then for material validation on learning instrument instruments, Figure 5 shows that two aspects have the highest value, namely the feasibility of content and science skills which have a percentage of 90%. Of the five aspects of the assessment, only the design aspect has the lowest percentage of 70%. This is due to the lack of researchers' ability to develop creativity (Sobari & Sucahyo, 2016).

Develop

The development stage is the final stage of developing the RLC series of teaching aids and learning tools after several revisions recommended by experts (Setiawan et al., 2021) . One of the results of media validation is replacing the capacitor component (from an electrolytic capacitor to a ceramic capacitor) and a switch (from a single-pole switch to a knife switch). At this stage, the RLC circuit demonstration will be tested to determine whether the data is in accordance with the theory of alternating current and voltage circuits, in addition to knowing whether this teaching aid is worth testing. This is also done to obtain variables used during the experiment (Affida, 2017). In the trial phase, the researcher obtained the appropriate experimental variables when applied in the classroom. The research variable is referred to as a term in research that is used as a causal relationship between the components of the tool and the results.

Figure 6. RLC circuit props

Implement

After validating the teaching aids and learning instruments by expert lecturers, it was found that the APRa-RLC teaching aids were declared suitable for use in research. Then researched 20 students of class XII MIPA SMA Tamansiswa Mojokerto. One of the purposes of the trial was to find out student responses and student learning outcomes during the learning process from beginning to end using the RLC series of props (Affandi et al., 2020) .

Cognitive learning outcomes obtained from the pre-test and post-test scores are shown in the table below,

Table 4. Recapitulation of n-gain test calculation results

Total students	Average Gain Score	Criteria
29	0.6	Currently

The table above shows the n-gain test scores obtained from the test, pretest, and pre-test scores by 29 class XII students. It was found that these results showed an increase in the assessment in the moderate category of 0.6 (Yunara & Iswanto, 2019) .

Evaluation

After the research has been conducted, the researcher analyzes the learning outcomes from three aspects: validity, effectiveness, and practicality. The RLC series props will be evaluated for their strengths and weaknesses in context or construction (Nomleni & Manu, 2018) . To find out this is done by distributing student response questionnaires. The results of the recapitulation of student responses to the RLC series props are in the following table,

Table 5. Recapitulation of the percentage of student responses

No.	Question	Percentage	Criteria
1.	I'm interested in learning physics using RLC circuit props.	86%	Very good
2.	Learning physics with RLC circuit props is very interesting and not boring.	85%	Very good
3.	Learning with RLC props makes it easier for me to remember material and physics formulas.	84%	Very good
4.	Learning with RLC props makes me more active and skilled.	82%	Very good
5.	Learning with RLC props gave me the experience of being an inventor like previous scientists.	82%	Very good
6.	These RLC props are easy to maintain.	83%	Very good
7.	The RLC circuit props function well when operated.	82%	Very good
8.	The RLC circuit props use an attractive appearance in color and shape.	79%	Well
9.	The RLC circuit props have good component resistance on the base.	82%	Very good
10.	Through the RLC circuit props, I found it easy to find and retrieve data easily.	78%	Well
	Amount	82%	Very good

From the recapitulation table of student responses, it can be seen that the results of student responses after learning activities with RLC props are included in very good criteria, which are based on the average value of student responses with a percentage value of 82%. This means that the RLC circuit props can specifically describe and facilitate teaching materials for alternating current and voltage electricity (Rahmat, 2019).

CONCLUSION

Based on the calculations and the study results, it can be concluded that the development of RLC circuit teaching aids is declared feasible as a medium for learning physics material in schools with alternating current and voltage electricity subjects. The effectiveness of the RLC series teaching aids on the knowledge aspect shows an increase in student learning outcomes in the n-moderate gain category with effective criteria. And the level of practicality of the developed RLC circuit props is in the efficient category. The overall conclusion can be stated as follows; based on the validation of teaching aids and instruments, the RLC circuit is categorized as valid and feasible to be tested.

RECOMMENDATION

Based on the research that has been done, the author recommends the RLC circuit display use RLC electronic components of more excellent value. Then you can also vary the manipulation variables by changing the value of the RLC electronic components to get a significant difference.

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