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The Development of Guided Inquiry-based Learning Worksheet Assisted by Livewire Simulations in Alternating Current

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Abstract

This research aims to design guided inquiry-based learning worksheets assisted by livewire simulation on a valid, effective, and efficient alternating Current material. The study method used to research and development designs. Development was carried out using the ADDIE model, which stands for analyzing, design, develop, implement, and evaluate. The subject of this research is the physics material alternating current material. The worksheets test subjects are students of class XII of Public Senior High School 8 Makassar (SMAN 8 Makassar), physics teachers, and media experts from Makassar State University. Data collection instruments utilized questionnaires, physics learning outcomes tests, and interviews. Data were processed using descriptive statistics then presented in the form of diagrams, tables, and graphs. The results showed that the development of guided inquiry-based worksheets assisted by livewire simulation was declared valid, effective, and efficient. In addition, students, teachers, and media experts had positive responses to guided inquiry-based worksheets development assisted by livewire simulation.

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Keywords: *ADDIE, Guided, Inquiry, Livewire, Physics, Simulation, Valid, Worksheets.*

1. Introduction

The 21st century is identic with the industrial revolution 4.0, which emphasizes the digital economy, artificial intelligence, big data, and robotic. The impact of this industrial revolution has penetrated the world of education, which demands creativity, critical thinking, mastery of technology, and digital literacy capabilities [1], [2]. The demands must start by strengthening the competence of educators at the forefront of education [3], [4]. Kereluik, Mishra, Fahnoe & Terry (2013) have conducted a critical review of the literature on 21st-century knowledge frameworks for teachers. They identified 15 reports, books, and articles that illustrate the types of knowledge that researchers say are an integral and essential part of success in the 21st century. The authors argue that a seemingly different framework meets three types of knowledge needed for the 21st century, namely basic, meta, and humanistic [5].

To anticipate the demands of the 21st century, the Indonesian government has made curriculum improvements at the elementary and secondary levels [6], [7].The curriculum is named the 2013 curriculum, which requires students to think creatively, critically, technologically sensible, and to have literacy skills. Unfortunately, at the school level, not all teachers can implement this 2013 curriculum, including at Public Senior High School 8 Makassar (SMAN 8 Makassar). Teachers in class still tend to put themselves as a source of learning. As a result, students tend to be passive in

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learning. This situation has led the teachers can barely implement the curriculum expectations optimally [8]. Physics teachers mainly experience this obstacle.

During the interview, the physics teacher said that the main obstacle faced was the unavailability of worksheets that required students to think critically. Even if there is, it is still constrained to certain materials. Besides, worksheets that have been used by teachers only require passive students and have not been assisted by computer simulations. After the interview, it was decided to develop worksheets that required active students to get facilitated by computer simulations. The use of worksheets with the help of simulations will not give satisfactory results without the use of learning models. The worksheets referred to the guided inquiry model with the aid of livewire simulation on the Alternating current material. Gittens, Kathy, and Calandrino (2015) proposed to apply an inquiry-based teaching model, specifically online guided and open inquiry [9]. The worksheets are defined as learning tools that contain guidelines for students to carry out activities programmatically [10].

These livewire simulation-assisted worksheets lead students to be active in learning. According to Pancawati (2016), livewire simulation is an electronic simulation that is used to design, analyze, and perform simulations in the form of animation and shows the workings of an electronic circuit [11]. The livewire simulation program is better than other simulations because it has a virtual laboratory bench, which can be tested using an oscilloscope, function generator, and others [12]. Besides, livewire help to learn drawing, stringing, and testing easily. As a result, students can do simulations in the form of interesting animations and provide an overview of the performance of electronic circuits.

In relevance to the development of the worksheets, the questions to be answered are as follows. How is the profile of guided inquiry-based worksheets aided by a valid livewire simulation? How to develop the guided inquiry-based worksheets facilitated by practical livewire simulations? How is the effectiveness of guided inquiry-based worksheets assisted by livewire simulations that have been developed?.

2. Literature Review

Learning is a process of interaction between the teacher and students to achieve teaching and learning goals [13]. Learning can occur everywhere and at different levels, individually, collectively, or socially [14]. In learning, students need a variety of learning resources. One of the more targeted learning resources is worksheets. Zulyadaini (2017), stated that Worksheets were created to help students to link problems with the subject matter in daily life [15]. Worksheets also contain instructions that are steps needed by students to complete assignments. Also, the worksheets include teaching materials, that are packaged in such ways by the teacher for students to learn independently [16].

Furthermore, Pratama, Minarni, and Saragih (2017) stated that students need worksheets as teaching material that can make them actively and creatively participate in learning to find concepts through solving daily life problems [17]. Also, Astuti, Purwoko, and Indaryanti (2017) said that worksheets are sheets for teaching material that aim to provide knowledge and skills in mastering the material [18]. Worksheets are guides used by students to conduct learning activities [19].

The utilization of simulation-assisted worksheets will be meaningful only if accompanied by a learning model. A learning model that uses a scientific approach, namely guided inquiry [20]. The guided inquiry learning model is a learning model that places students into scientists who seek to understand nature as an application of science and can explain what they observe [21].

Moreover, worksheets will be useless without subjects that matter to be developed. In this research, the material developed is alternating current. The first material in this alternating current is alternating current and voltage. Electric current and voltage generated by the generator are sinusoidal voltage and electric current. (figure 1). The magnitude of the voltage and the strength of the electric current as a function of sine often expressed in the phasor diagram. If the generator is connected to a conductor R and produces a maximum voltage of Vmax, then the voltage and electric current can be seen [22].

$$V = V_{max} \sin \omega t \quad (1)$$

$$I = I_{max} \sin \quad (2)$$

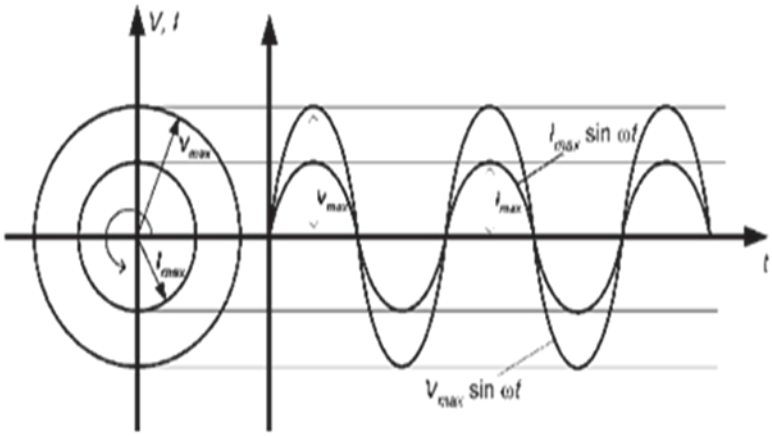

Figure 1. Alternating Current and Voltage Graph as a Time Function

The effective value of alternating current and voltage is equivalent to the direct current at the same time. If it flows through the same electrical resistance, it will produce the same heat. The relationship between sufficient value and maximum value can be stated [22],

$$V_{ef} = \frac{Vmax}{\sqrt{2}} = 0.707\ V_{max} \quad (3)$$

$$I_{ef} = \frac{I\ max}{\sqrt{2}} = 0.707\ I_{max} \quad (4)$$

The relationship between the average value of the current and the alternating current voltage value and the maximum voltage, determined [22],

$$I_r = \frac{2\ Imax}{\pi} \quad (5)$$

$$V_r = \frac{2\ Vmax}{\pi} \quad (6)$$

The alternating current can be taught by using a livewire simulation program. Livewire 1.11 computer program is an electronic simulation program that is used to design and analyze. It is displayed in the form of animation and can make sounds to demonstrate the functions or fundamental principles of electrical circuits [23]. Livewire is a sophisticated software package for designing and simulating electronic circuitry and is a product of the New Wafe Concept. The Livewire-Professional Edition program version 1.11 is a licensed program that is available at http://www.newwave-concepts.com and protected by copyright law. Many electronic components can be utilized in LiveWire, such as resistors, capacitors, ammeters, DC, and AC voltage sources, and others.

The livewire program has a virtual laboratory bench that can be tested by using an oscilloscope, function generator, and others. The livewire program will help the learning of stringing and testing quickly. This program can help students to do the design of electronic circuits. Apart from that, it is also for analysis and simulation of electronic circuits with interesting-looking animation. The livewire program can be used as computer-assisted instruction (CAI) software, which is an instructional model that involves students with computers directly. The CAI mainly consists of drills and practices, simulations, and games.

3. Research Method

This research was a Research and Development (R&D) model, which is established by Borg and Gall (1983) [24]. The Worksheets development model adapted the ADDIE model developed by

Branch (2009) [25], which stands for analyzing, design, develop, implement, and evaluate [26]. The concept of the ADDIE development model can be seen in Figure 2 below.

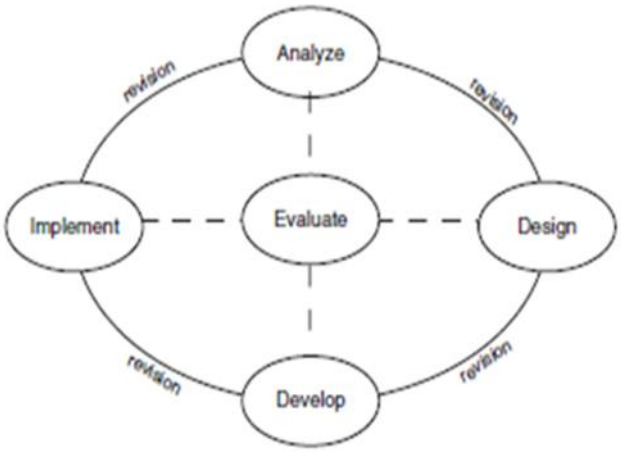

Figure 2. ADDIE Development Model Flow [25]

A questionnaire was used for assessment by media experts to know the optimization of the worksheet's implementation. Indicators of the worksheets assessment for media experts are the appropriateness of the content, presentation, language, and graphics. Meanwhile, the assessment questionnaire was utilized by students and teachers to find out the effectiveness of the application of worksheets.in this state, Indicators of assessment of worksheets for students consists of student's interest in worksheets, student's perceptions of the worksheets material, and student's perceptions of the language used in the worksheets. On the other hand, the assessment indicators for teachers are the same as indicators for media experts with additions of completeness and implementation.

All instruments were assessed by experts to determine content validity, and the results of the assessment were analyzed using the Gregory equation (2015) [27]. The results of the internal consistency analysis of each instrument were obtained as follows, the rii student questionnaire = 0.89, the rii teacher questionnaire = 0.91, the learning achievement test by rii students = 0.87, and the survey by rii media expert = 0.93. Thus, all instruments used in this study have met the content validity criteria.

Furthermore, an empirical trial was conducted at SMAN 8 Makassar to determine the validity of the instrument criteria. The subjects of this trial were 60 students of Class XII and 2 of physics teachers. The validity of the questionnaire criteria was calculated using the Pearson product-moment correlation formula [28], [29], and the reliability was measured with the Cronbach's alpha formula [30]. Likewise, the validity of the test item criteria was determined by the biserial point equation [31] and the reliability of the test using the KR-20 formula [32]. This research was conducted in the second semester of the 2019/2020 school year. The research data were then presented in descriptive static form in the form of chart tables and graphs.

3. Research Results and Discussion

3.1. Analyze

This stage contained an analysis of student needs. According to the preliminary observation, Students XII Grade at Public Senior High School 8 Makassar (SMAN 8 Makassar) has been learning from teachers based on textbooks. However, such a learning model is dominated by teachers, while student involvement is still less. This causes the activities of the student to become very passive. Besides that, students of SMAN 8 Makassar rarely do lab work, even though physics is identical to learning and practicum. Notably, the topic of learning about Alternating Current, that requires more intensity of practicum.

Based on the facts above, it was decided that Class XII students of SMAN 8 Makassar need more learning media. The media that is suitable for the characteristics of alternating current material and has never been applied at SMAN 8 Makassar, which is Livewire simulation. Therefore, guided

inquiry-based worksheets assisted by Livewire simulation were proposed to help in learning physics Alternating Current material. These worksheets consist of four primary materials, which are alternating current and voltage, alternating current electrical circuits, RLC series circuits, and power in alternating current circuits.

3.2. Design

This phase was developed according to the analysis of student needs. At this stage, concept maps regarding alternating current material and learning objectives were evolved. Then, the worksheet's material was packaged with the guided inquiry learning approach. The first step was to describe the Alternating Current and Voltage. After the learning session conducted, then the presentation was designed with the help of Livewire simulation. Next, in the worksheets, the symbols, menus, facilities, and operating techniques of livewire simulation were introduced first. The work steps of each worksheet were directed to guided inquiry-based learning. As for the following material, everything was designed according to the steps outlined previously.

3.3. Develop

At this stage, all concepts and designs were developed. The development was still based on the analysis of student needs. The results of the development of the 1st stage design worksheets with topics alternating current and voltage can be seen in Figure 3 below.

Topics : Alternating current and voltage

Right-click on the **Digital Multimeter** component, then select **mode** and select Ohm as shown below,

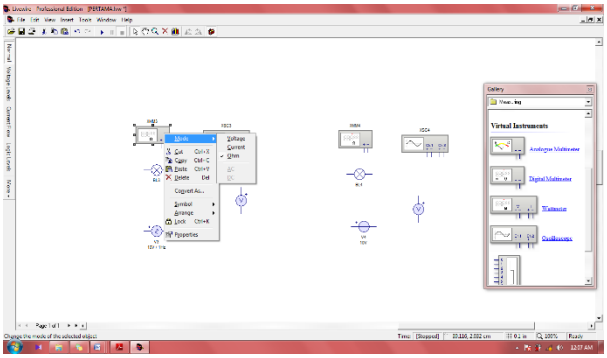

Figure 3. The Result of One of the Worksheets Developments

Also, on the next worksheets could be developed up to the 4th worksheets with topics Power in the alternating current circuit. The results of the development of worksheets can be seen in Figure 4 below.

Topics : Power in alternating current circuits

Then connect all the components so that the RLC circuit is formed as shown below

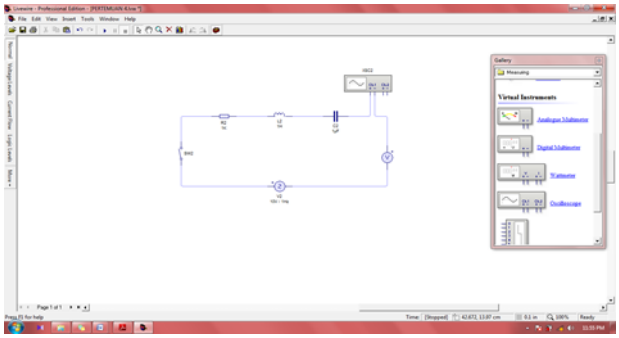

Figure 4. The Result of Worksheet Development

3.4. Implementation

The next stage was the implementation model of guided inquiry-based learning worksheets helped by livewire simulations in learning in schools. Before the worksheets were implemented, they had been assessed by learning media experts. According to them, the model has met the eligibility criteria for content. The content eligibility is guided by the essential competencies set out in the Content Standards, one of the parts of national education standards in Indonesia. The percentage of content feasibility was 97.50%, and for the components of presentation feasibility, language feasibility, and graphic eligibility were above 90%. This means that all the feasibility has been fulfilled, and the worksheets are declared valid. The results of the assessment of the four feasibility components, as described, can be seen in table 1.

Table 1. Results of Learning Media Expert Assessment of The Model

No.	Aspect	Mean of each aspec	Percentage (%)
1	Feasibility of content	3.90	97.50
2	Feasibility of presentation	3.70	92.50
3	Feasibility of language	3.68	92.00
4	Feasibility of graphics	3.86	96.50

Source: Primary Data Processed (2020)

These results are similar to the results of the development that has been carried out by Ulum, Soetjipto, and Yuanita (2019), who reported that the quality of physics learning development based on guided inquiry supported by PhET simulations was declared valid. The result of learning components includes syllabus, student textbooks, and worksheets [33].

3.5. Evaluation

After the five steps that had been carried out, the next stage was evaluation. At this stage, students were asked to respond to the use of the model. Questionnaires were given to students as many as 30 items, by adapting the Likert scale. The number of items for indicator-1 was 11, indicator-2 was 11, and indicator-3 was 8. The highest empirical score obtained by students was 121, and the lowest was 94. The results of the analysis of student responses can be seen in Figure 5 below.

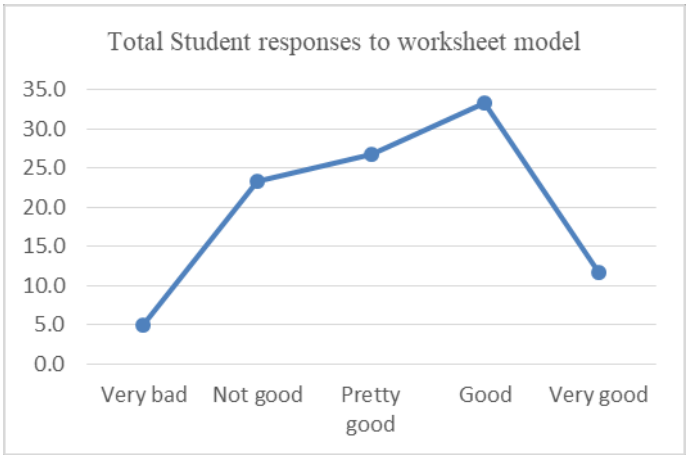

Figure 5. Student Responses to The Worksheet Model

Figure 5 above indicates that most (33.3%) students responded that the proposed model worksheet that researchers had developed could be used well. Furthermore, the student's responses that were analyzed for each indicator developed, it can be seen in Figure 6 below.

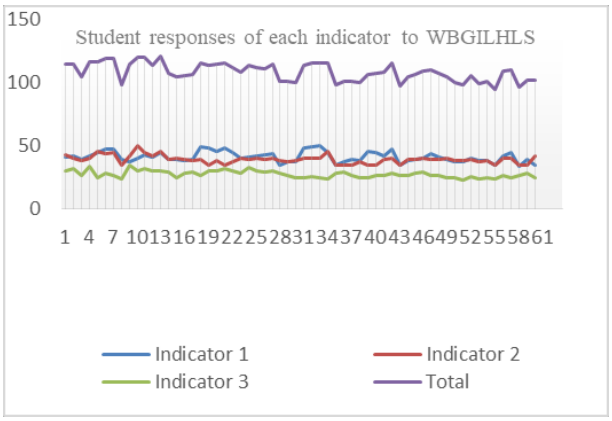

Figure 6. Graphic of Student Responses on The Worksheet Model for Each Indicator

Figure 6 above describes that the graph of student responses both overall, and each indicator tends to be consistent, which means it shows a positive reaction to the model. Therefore, according to the student's perceptions, the worksheet model can practically be used in learning physics, especially Alternating Current material.

After the worksheets were implemented in learning, students were given a physics learning achievement test. After analyzing the learning outcomes, the student learning achievement can be seen in Figure 7 below.

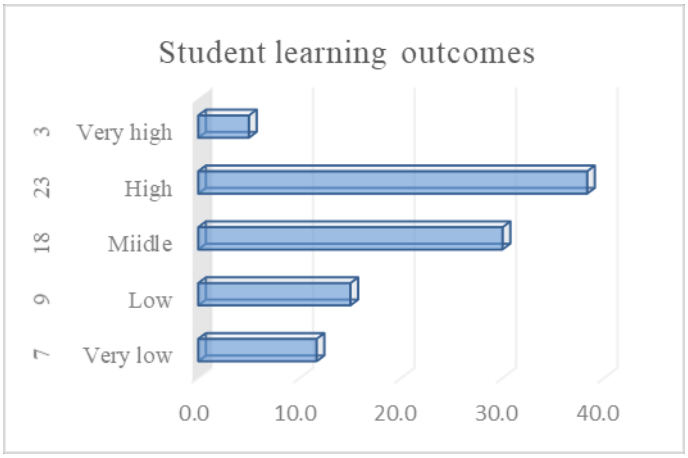

Figure 7. Graphic of Student Learning Achievement After Utilizing The Worksheet Model

According to Figure 7 above, it appears that in general, students have fully understood the concepts in the material presented through the model. Students can choose the right tools and relevance between the concepts of Flow and Voltage with other materials. The assessment results of 60 students, it is obtained 23 students or 38.3% who have a score of learning outcomes that are categorized as high. There are 18 students or 30% in the medium category. Based on student learning outcomes data that has been shown above, it can be concluded that the model is effectively used in physics learning.

Similar research has been carried out by Repdayanti, Mawardi, and Oktavia (2018) on the development of guided inquiry-based worksheets. The results of the study indicate that the development of guided inquiry-based worksheets has been valid, practical, and effectively used in the process of learning chemistry at the level of the reaction material [34]. On the other hand, Umriani, Suparman, Hairun, and Sari (2020), that have conducted research aimed at designing worksheets with problem-based learning models to improve student's creative thinking skills shows still low [35].

Moreover, according to the teacher's response to the use of the model in learning for each indicator, can be explained as follows. Teacher response indicators consist of six indicators, namely,

the appropriateness of content, presentation, language, graphic, completeness, and feasibility. Overall, the average score of each indicator can be seen in Table 2 below.

Table 2. Indicators of Teacher Responses to The Model

No	Indicators	Mean of each indicator	Percentage (%)
1	Feasibility of content	3.92	98.00
2	Feasibility of presentation	3.65	91.25
3	Feasibility of language	3.64	91.00
4	Feasibility of graphics	3.82	95.50
5	Completeness	3.68	92.00
6	Implementation	3.72	93.00

Source: Primary Data processed (2020)

Based on table 2 above, it appears that the feasibility of the content occupies the largest percentage, then followed by the feasibility of graphics. This presents that the developed model fulfils the content of a worksheet. The appropriateness of material refers to the basic competencies to be achieved in learning. Likewise, the feasibility of the graphic shows that the resulting average is quite high. This indicates that the display of images, fonts, and size fonts are used in the model is quite good. This further proves that the developed model meets the graphic aspect. If the teacher's response is presented in a spider diagram, it will look like in figure 8 below.

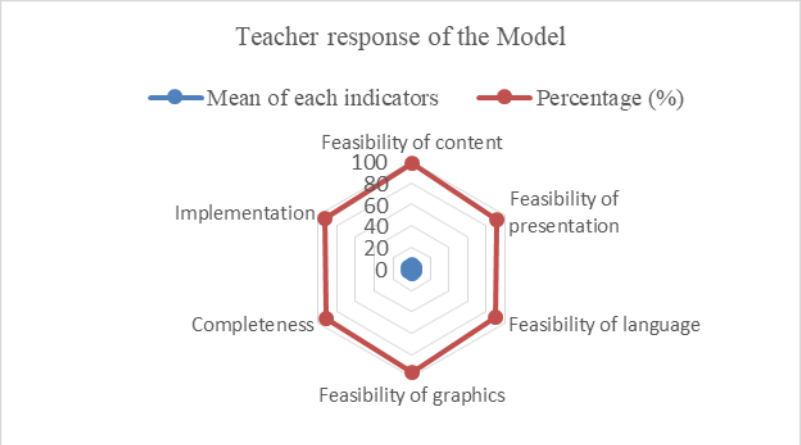

Figure 8. Spider diagram of Teacher-Responses Towards The Model

In general, the teacher's response to the model on the Alternating Current material is in the excellent category. It appears that the teacher's response to each indicator is above a score of 3 from a possible score of 1-4 or a percentage above 90%. This shows that the developed model was appropriate to be used by the teacher in learning. This result is supported by research conducted by Windiastuti, Suyono, and Kuntjoro (2018) [36]. They reported that teachers like to use learning tools that have been developed because they are practical and useful. Similarly, the results of the development carried out by Nurahman, Widodo, Ishafit, and Saulon (2018) indicated that the appearance and language of guided inquiry physics learning worksheets are perfect and worthy of being used as a source of learning [37].

Lastly, after interviewing the teachers of SMAN 8 Makassar about the use of the developed model, they agreed that the model is very useful in education. Moreover, the use of the model is beneficial for students and teachers in lockdown periods these days, in which The local Government of Indonesia applies large-scale social restrictions to break the chain of transmission of COVID-19. So, the teacher is much helped by the worksheets developed model, which related to work from home implemented by the Indonesian government.

4. Conclusions

According to the results of the analysis and discussion that has been stated, it can be concluded that,

1. The guided inquiry-based worksheet assisted by the livewire simulation that has been developed is declared valid for the teacher to use in the learning process. This statement is indicated by the response of media experts and teachers who are very positive towards the worksheets.
2. The developed Guided inquiry-based worksheets based on livewire are declared practical. This is indicated by the response of students and teachers who are also very positive towards worksheets.
3. The developed model has been declared effective for teachers to use in learning. This is proved by the student learning achievement obtained after using these Worksheets in the high category.

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