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# Developing digital teaching module with problem-based learning integrated to virtual lab on electricity

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**Abstract**

*Science learning is empirical learning that involves the process of investigation. However, limited facilities and infrastructure, and the unavailability of laboratories are obstacles in the process of investigating science learning. Traditional laboratories require much time, cost and performance, so using virtual laboratories can be an alternative in science learning. The problem-based learning model can guide the use of virtual laboratories in science learning. Thus, this study aims to develop and test the feasibility of digital teaching material products based on problem-based learning integrated with virtual laboratories on electricity material for PGMI students. The product development process refers to the Lee & Owens development model, which consists of analysis, design, development, implementation and evaluation. The data collection instrument consists of a media validation test instrument, material validation test and readability test in the form of a questionnaire with a Likert scale. The results of the media validation test showed a percentage score of 92.33% with very valid criteria. In comparison, the readability test generated a score of 83.25 with very valid criteria. Thus, digital teaching materials based on problem-based learning integrated with virtual labs on electricity material are proven to be valid and feasible for use in science learning for PGMI students.*

## INTRODUCTION

### Background of the Study

The current era of the 21st century is characterized by the development of science from time to time which brings significant changes to the development of science and information technology (Serrano-Perez dkk., 2023). In the field of education, technology provides opportunities to develop and improve the learning process (Songer, 2013). Effective use of technology in the learning process can


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increase the effectiveness of learning (Crompton dkk., 2016). Over the past two decades, the application of technology in the learning process has been confirmed to be effective for complex science learning (Nawzad dkk., 2018).

The essence of science learning is not only related to the content of science materials, but also the process. Physics is one part of science that is closely related to the systematic analysis of natural phenomena. Some physics and science concepts are abstract concepts that are often an obstacle to visualizing these concepts (Cahyaningtyas & Ismiyanti, 2022). Therefore, learning physics or science is not just a collection of knowledge such as facts, concepts or principles, but science learning also involves a process of investigation.

Science learning is empirical learning that requires experimentation or practicum, practicum-based science learning can improve observational skills, understanding of scientific concepts and scientific attitudes (Malik & Ubaidillah, 2021; Oladejo & Ebisin, 2021). Science learning using practicum can provide opportunities for students to construct their own understanding of concepts (De Jong dkk., 2013).

## Problem of The Study

Science practicum is very rarely applied in learning for the main reason of lack of infrastructure and laboratory space. This is also in line with the initial observations that have been carried out in the Madrasah Ibtidaiyah Teacher Education study program at UIN Maulana Malik Ibrahim Malang, which does not yet have a science laboratory to support the learning process. Thus, the science learning process rarely applies practicum. Students are often asked to bring some tools that are easily obtained in the surrounding environment, to carry out traditional practicum. However, traditional practicum takes more time to prepare, lacks the necessary equipment, and costs more money (Manyilizu, 2023; Penn & Ramnarain, 2019).

In addition, the results of the needs analysis questionnaire show that students find it most difficult in electrical material. Students' learning difficulties in understanding dynamic electricity material on the subject of current, voltage and electrical resistance are quite high (Handayani dkk., 2017; Nofitasari & Sihombing, 2017). This is because students often have difficulty determining the direction of abstract electric current and mathematical operation difficulties. In addition, these difficulties also occur due to the lack of variations in media and learning methods (Nofitasari & Sihombing, 2017; Siswanto, 2016).

## Research's State of the Art

Based on the lack of facilities and infrastructure, especially in terms of laboratories, virtual practicum becomes an alternative in the implementation of learning. Virtual lab is a computer program to simulate experimental investigations without doing activities directly, so that virtual lab can facilitate activities that cannot be practiced in real life (Ismail dkk., 2019). Virtual lab is a virtual interactive space that combines technology, pedagogic and human resources to carry out practicum in a virtual environment (Solikhin dkk., 2019).

The use of virtual labs can save time, money, and performance (Aljuhani dkk., 2018). Most of students strongly agree on the use of virtual labs as learning media to support the practicum process (Maulidiana et al., 2021) . The majority of students strongly agree on the use of virtual labs as learning media to support the practicum process (Ismiyanti & Cahyaningtyas, 2019). Virtual lab can represent macroscopic, symbolic and microscopic material (Herga dkk., 2016).

Virtual laboratory cannot stand alone in a learning process. Problem-based learning model is very suitable to be integrated with virtual lab. Problem-based learning encourages students to construct their understanding through the process of investigation and collaborative learning. Problem-based learning can increase student motivation (Suari, 2018), learning outcome (Gulo, 2022), science literacy (Hartati, 2016; Kimianti & Prasetyo, 2019), and critical thinking (Devi & Bayu, 2020).

## Novelty, Research Gap, & Objective

Problem-based learning model has become an interest in itself at the higher education level. (Jensen dkk., 2019; Santateresa, 2016). Several studies have integrated PBL learning models with traditional practicum-based learning. (Alfiah & Dwikoranto, 2022; Medriati, 2003). However, the integration of practicum-based learning is still traditional, while the integration of virtual laboratories and PBL in science learning in the form of digital teaching materials for prospective teachers at the university level is still limited. Thus, this study aims to develop products and test the validity of digital teaching materials based on problem-based learning integrated with virtual laboratories on electricity material for PGMI students at UIN Maulana Malik Ibrahim Malang.

## METHOD

### Type and Design

The development of science digital teaching materials based on Problem Based Learning Integrated Virtual Lab on electricity material refers to the Lee & Owens (2004) development model. The development model is in accordance with the development of multimedia-based teaching materials. The development model consists of five stages, namely assessment/analysis, design, development, implementation and evaluation, as presented in Figure 1. This development research is limited to the first three stages, namely assessment/analysis, design, and development, because this research focuses more on the process of product development of digital science teaching materials based on Problem Based Learning Integrated Virtual Lab. While the implementation and evaluation stages will be continued in further research

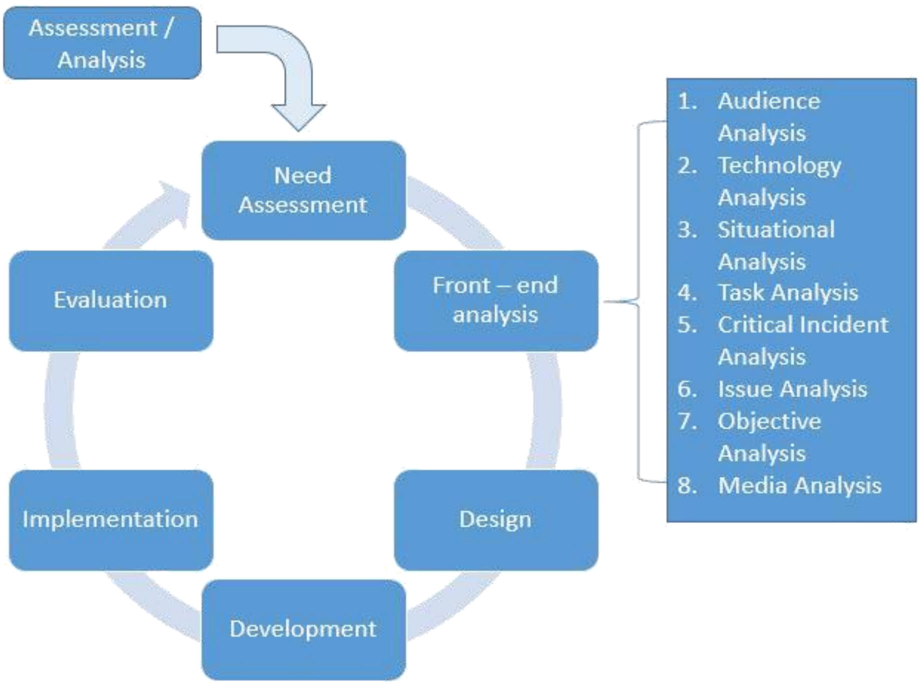


**Figure 1.** Lee & Owens Development Model

The first stage in the Lee & Owens development model is the analysis stage. At this stage, the researcher makes observations to explore the state of the research subject, the environment, and learning barriers. This analysis stage consists of two steps, namely need assessment and front-end analysis. The needs analysis was carried out by distributing online questionnaires to PGMI students at UIN Maulana Malik Ibrahim Malang, UIN Sunan Ampel Surabaya, UIN KHAS Tulungagung, IAIN Kediri and IAIN Ponorogo. Result of analysis by Amelia, (2023) which shows that science learning in PGMI PTKIN East Java students requires digital teaching materials integrated with Problem Based Learning to support blended learning in the East Java PTKIN environment. The results of the needs analysis are the basis for the development of science digital teaching materials based on Problem Based Learning Integrated Virtual Lab on electricity material.

The second stage is design. At this stage, researchers compiled a storyboard as a reference for the process of developing digital science teaching materials based on Problem Based Learning Integrated Virtual Lab. Storyboards are compiled to determine the components contained in digital science teaching materials based on Problem Based Learning Integrated Virtual Lab. Storyboards also need to describe the features contained in teaching materials, for example the introduction menu, material content menu, worksheet menu accompanied by virtual lab, and learning evaluation menu.

The next stage is the development stage. This stage contains production and post-production stages. At the production stage, digital science based on Problem Based Learning Integrated Virtual Lab on electricity material began to be developed starting from material content, student worksheet content accompanied by virtual labs, and learning evaluation content using online learning evaluation applications. While in the post-production stage, researchers tested the feasibility and validity of digital science teaching materials based on Problem Based Learning Integrated Virtual Lab that had been developed to expert lecturers and student responses. The validation test consists of media validation tests, material validation tests, and student readability tests of the digital teaching materials developed.

### Data and Data Sources

The data in this study consisted of primary data and secondary data. Primary data consists of data from needs analysis results, material validation test results, media validation test results and readability test results of PBL-based digital teaching materials integrated with Virtual Lab. While the primary data sources consist of material expert lecturers, media expert lecturers, and students as users of digital teaching materials. Secondary data includes data on the difficulties of prospective teacher students on electrical material and analysis of the availability of digital teaching materials in science learning. Secondary data sources include literature reviews based on relevant previous research.

## Data Collection Technique

Data collection techniques for the development of digital science teaching materials based on Problem Based Learning Integrated Virtual Lab on electricity material consist of questionnaires, observations and interviews. Questionnaires include material expert assessments, learning media experts, and readability tests. This questionnaire uses a Likert scale with a value component between 1-5, with 1: Strongly Disagree, 2: Disagree, 3: Moderately Agree, 4: Agree, and 5: Strongly Agree. Observation aims to determine student responses when using digital science based on Problem Based Learning Integrated Virtual Lab on electricity material. While the interview aims to find out the responses of expert lecturers and students related to suggestions / criticisms related to digital science teaching materials based on Problem Based Learning Integrated Virtual Lab on electricity material.

## Data Analysis

Data analysis of research on the development of digital science teaching materials based on Problem Based Learning Integrated Virtual Lab on electricity material is related to data analysis of the results of media validation tests, materials and readability tests. Media validation tests, materials and readability tests in the form of questionnaires with Likert scale assessment components ranging from 1-5. The results of the Likert scale were then analyzed using percentage analysis techniques. Furthermore, the percentage is averaged and the criteria are determined. The criteria for interpreting the average analysis score are presented in Table 1.

**Table 1.** Criteria of Average Analysis Score Interpretation

| Persentase (%) | Kriteria |
|---|---|
| 0 – 20 | Very weak / unfit/ invalid |
| 21 – 40 | Weak / Less fit / less valid |
| 41 – 60 | Fair / Fairly Fit / Fairly Valid |
| 61 – 80 | Strong / Fit / Valid |
| 81 – 100 | Very Strong / Very Fit / Very Valid |

## RESULTS

### Desciption of Development Result

The product of this development research is digital teaching materials based on scaffolding problem-based learning integrated with virtual laboratories that can be accessed on the page https://bit.ly/bahanajar-kelistrikan. This digital teaching material contains material about static electricity and dynamic electricity. This webpage consists of an introductory section on the homepage and a core material section consisting of static and dynamic electricity.

1. Home (Introduction)

In the home section, there is an overview page of electrical material, learning outcomes, a menu leading to the core material of static and dynamic electricity, reference book links and developer profiles. The home page is the initial page that appears when students open this digital teaching material.


**Figure 2.** Homepage: Overview of Teaching Module and Learning Achievement

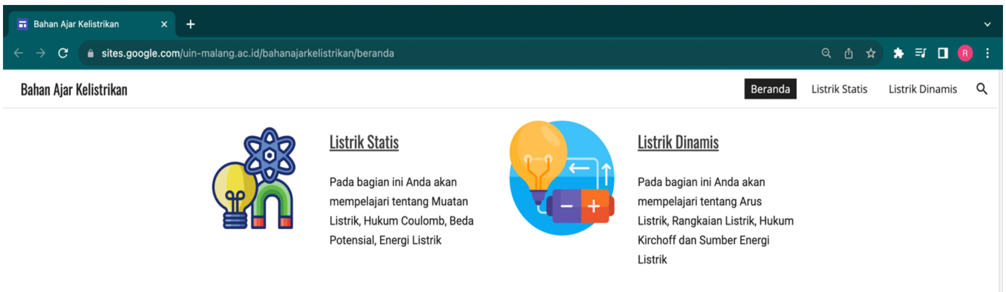


**Figure 3.** Homepage: Teaching Module Menu

2. Content (Core Material Content)

After the user selects one of the materials, the user will be directed to the core part of the material. The core material consists of the home page, the context of the problem, the formulation of the problem and hypothesis, let's look closely and let's evaluate. Each page description in the core material content section is explained as follows.

a. Homepage

When the user selects one of the materials on the menu on the Home page, the user will be directed to the display of the material's home page which shows the initial description of the material and several menus, namely the worksheet menu, let's examine and let's evaluate.

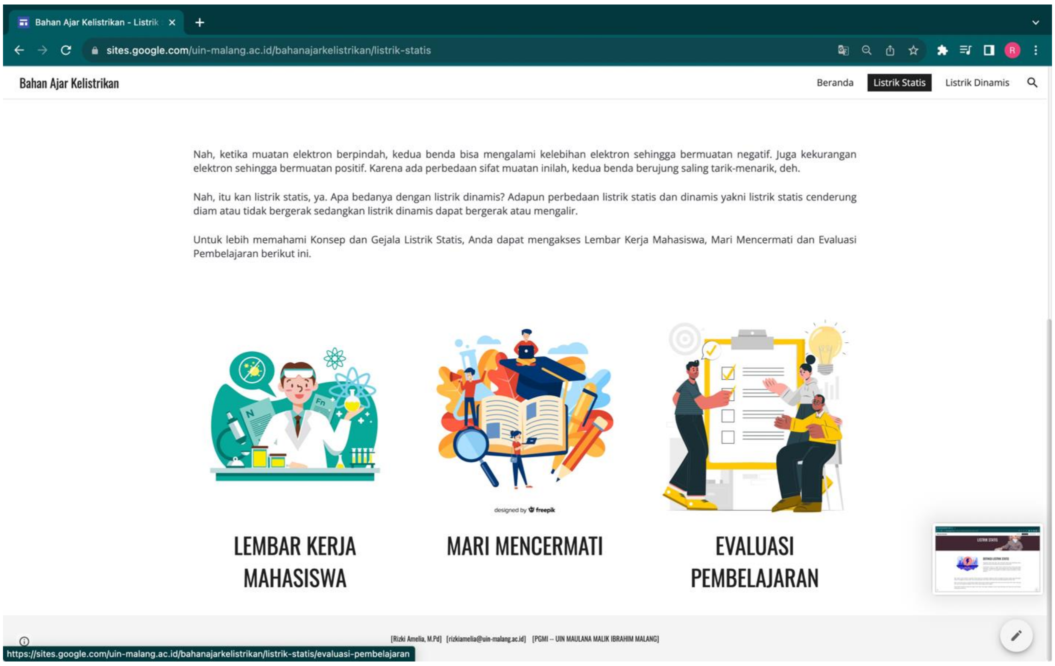


**Figure 4.** Menus on the First Page of Material Menu

b. Student Worksheets

The menu on the initial page of the material is the student worksheet. In this student worksheet menu, users will be directed to explore the material content by doing several activities. The Student Worksheet menu consists of a problem context menu, problem formulation and hypothesis, let's explore, and observation results and data analysis.

In the context of the problem, students are given applicative problems related to the material to be studied, the context of this problem is in the form of a case equipped with a video that can be accessed directly in this electrical teaching material. After observing the context of the problem, students are then directed to formulate problems and hypotheses in accordance with the context of the existing problem. The formulation of problems and hypotheses made will be directly connected to the mentimeter and will be directly recorded on the lecturer's account. The display of the problem context and problem formulation is presented in Figure 5.

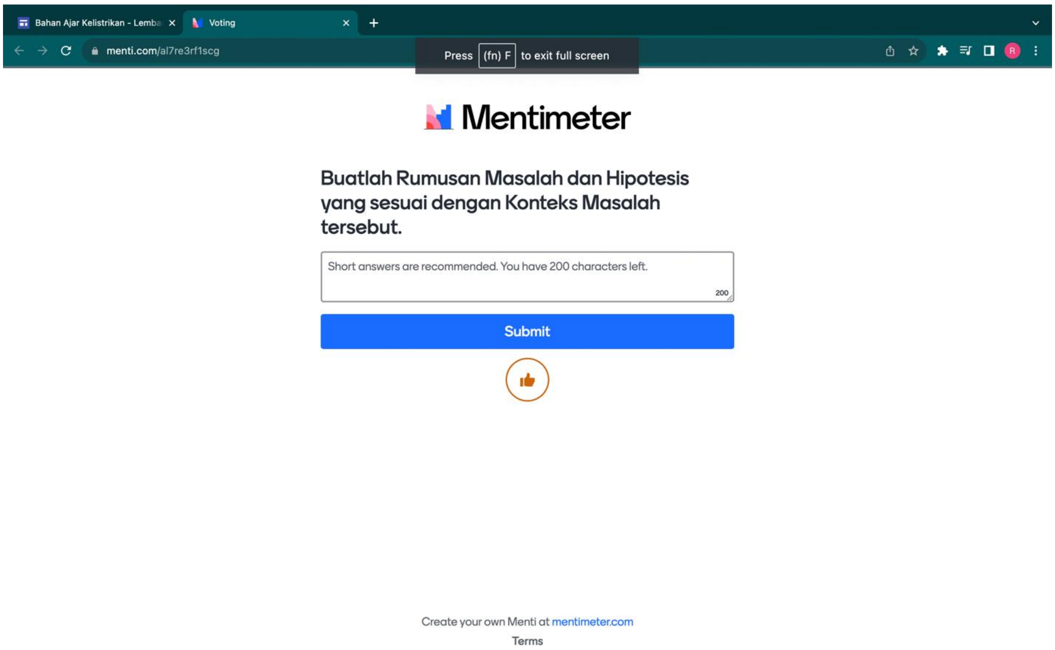


**Figure 5.** Page View of Statement of Problem and Hypothesis linked to Mentimeter

After students input the formulation of problems and hypotheses, then students are directed to do practicum online using virtual laboratories in the let's explore section. This section is equipped with practicum procedures and integrated with the Phet virtual laboratory application. Thus, students can directly carry out online practicum on the website of this electricity teaching material without having to open a new application again. The virtual lab display is presented in Figure 10.

After students carry out practicum using a virtual laboratory, students are directed to write down the results of observations and data analysis of practicum results on student worksheets in the observation results and data analysis section. This Student Worksheet is integrated in teaching materials, so students can write directly the results of their observations and send their answers to the lecturer's account. This worksheet is an embedded application of the liveworksheet. The student worksheet display is presented in Figure 6 and Figure 7.

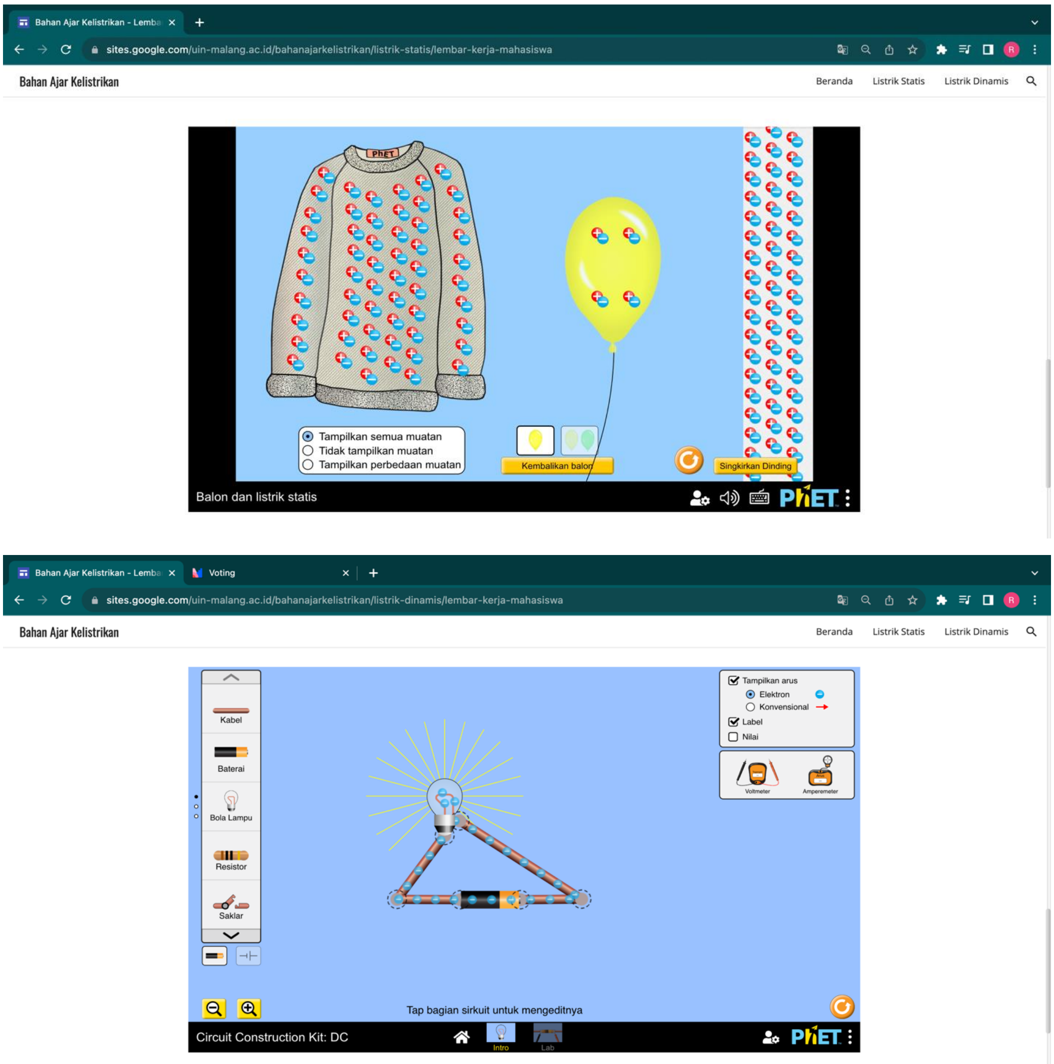


**Figure 6.** View of Virtual Lab for Static and Dynamic Electricity Course

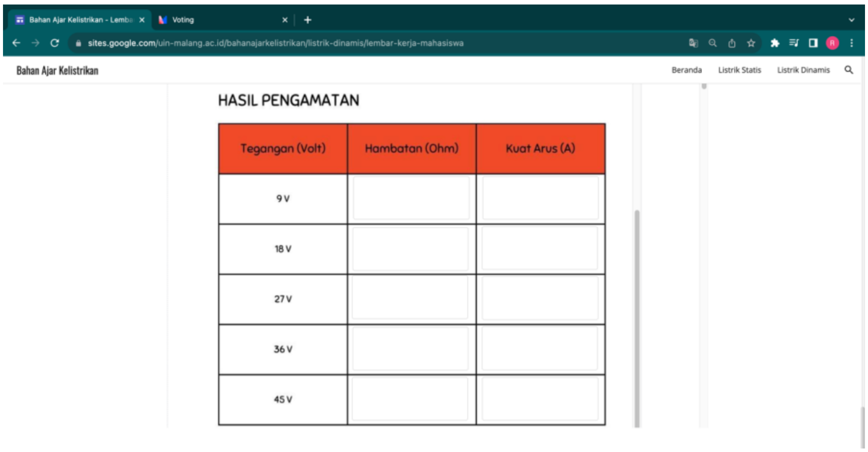


**Figure 7.** View of Student Worksheets Integrated to Live Worksheet

c. Mari Mencermati

After students have completed the practicum, students are directed to look at related material. In this menu there is a brief explanation of the material and also some sample questions related to the material. The Mari Mencermati menu display can be seen in Figure 8.

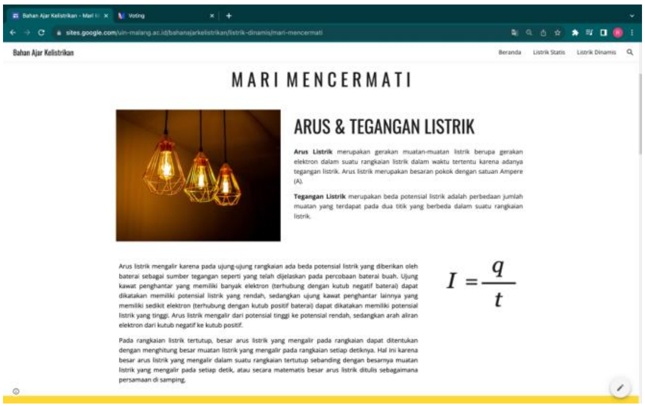


**Figure 8.** View of Mari Mencermati Menu

d. Learning Evaluation

Furthermore, to test students' understanding of the material that has been learned, students are directed to access the learning evaluation. This learning evaluation is also integrated in the website of this teaching material. The learning evaluation is in the form of multiple choice questions that look like games, so that it can attract student interest in learning. This learning evaluation is prepared using the quizwhizzer application. The results of learning evaluations that have been carried out by students are also sent directly to the lecturer's account. So that lecturers can also monitor the learning progress that has been done by students. The Learning Evaluation Menu display is presented in Figure 9.

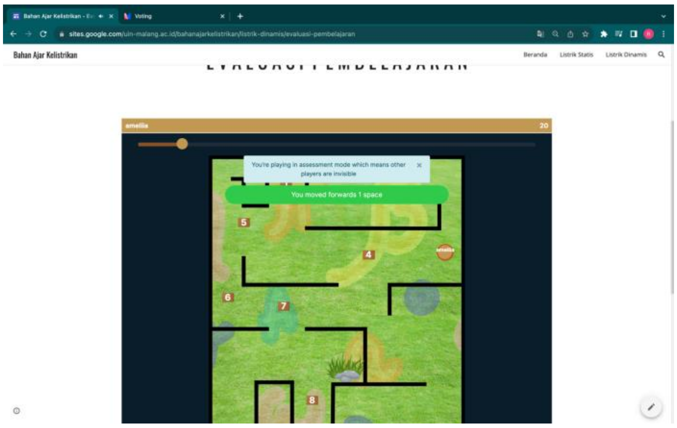

**Figure 9.** View of Learning Evaluation Questions

## Description of Product Validation Result

The results of product validation of PBL-based digital science teaching materials integrated with virtual labs consist of the results of material validation, media validation and readability tests. Data on the results of validation and readability tests obtained from questionnaires in the form of quantitative and qualitative data. Qualitative data in the form of suggestions and comments obtained from validators and students. The quantitative data obtained is the average score of the questionnaire according to the Likert scale with a score of 1-5. Furthermore, the data from the questionnaire was analyzed descriptively with a percentage of the score per question item. The results of quantitative data analysis show the feasibility and readability of digital teaching materials. The results of validation and readability tests are described in Tables 2 and 3.

**Table 2.** Result of Media Validation

| No | Aspect | Val.1 | Val.2 | Average | Criteria |
|---|---|---|---|---|---|
| 1. | Presentation | 89,41% | 91,18% | 90,29% | Strongly Valid |
| 2. | Language | 92,5% | 96,25% | 94,37% | Strongly Valid |
| **Average of Media Validation Test Result** | | | | **92,33%** | **Strongly Valid** |

**Table 3.** Result of Readability Test on Science Digital Teaching Module

| No. | Aspect | Percentage | Criteria |
|---|---|---|---|
| 1. | Attractive Design | 87,2% | Strongly Valid |
| 2. | Easy to Use | 84% | Strongly Valid |
| 3. | Videos in the module ease readers to comprehend the mechanic material | 87,2% | Strongly Valid |
| 4. | Virtual practice in the digital module provide assist in understanding the material | 80% | Valid |
| 5. | Motivate readers to comprehend mechanics material | 78,4% | Valid |
| 6. | The contents presented in the digital module relates to daily life | 82,4% | Strongly Valid |
| 7. | Easy-to-understand materials | 81,6% | Strongly Valid |
| 8. | Contains questions for practice to test understanding about mechanics | 85,6% | Strongly Valid |
| 9. | The material presentation helps readers to develop problem-solving skill | 82,4% | Strongly Valid |
| 10. | The material presentation helps readers to develop scientific reasoning skill | 85,6% | Strongly Valid |
| 11. | Font type, model and size are simple and readable | 80,8% | Strongly Valid |
| | **Average** | **83,2%** | **Strongly Valid** |

Data on the results of validation of digital teaching materials are obtained from several aspect assessments by validators. This validation aims to determine the feasibility of digital teaching materials that have been developed. In this development research, two types of validation were carried out, namely material validation and media validation. Material validation consists of aspects of content feasibility, language and aspects of independent learning.

The first aspect of material validation is the content feasibility aspect. In the content feasibility aspect, there are several eligibility indicator points, including the clarity of the details of the material to be studied, the suitability of the material with the learning outcomes, the material in accordance with the learning objectives, the completeness of the learning material, the material is easy for students to understand, the material can motivate learning, the material is in accordance with the level of student ability and the clarity of the included examples.

The second aspect of material validation is the aspect of language feasibility. In the aspect of language feasibility, there are several indicator points, including the language used is easy for students to understand, the sentences used are easy to understand, the sentences used do not cause double meaning, conformity with Indonesian language rules, the language used is in accordance with the level of development of student thinking.

This readability test aims to determine the ability of students to understand the contents of digital teaching materials, so that it can be seen whether teaching materials are suitable for use in the learning process or not. This readability test shows that most students are very interested in the digital science teaching materials developed, this is because this teaching material is equipped with virtual practicum. Based on the description of quantitative data, the results of the validation of the readability test of digital teaching materials amounted to 83.2%. Thus, the digital teaching materials that have been developed are very feasible to use in learning and can develop the ability of science process skills and understanding of student concepts.

## DISCUSSIONS

Science digital teaching materials are needed in science learning in the environment of State Islamic Religious Universities in East Java. Science digital teaching materials are developed with the Lee & Owens development model. Based on the results of validation and readability tests, it was found that in general, science digital teaching materials are valid and feasible to use as digital teaching materials in science learning. This science digital teaching material uses a flow of learning activities based on Problem Based Learning. Digital teaching materials based on problem-based learning can encourage students to think critically (Agustina & Fitrihidajati, 2020; Endaryati dkk., 2021), solve problems (Setyoko dkk., 2019), encourage students to actively participate in learning, and to improve concept understanding (Pramana dkk., 2020; Savitri dkk., 2022).

During the post-Covid-19 blended learning period, this science digital teaching material can support independent learning for students. With this digital teaching material, students can learn science material anytime and anywhere. In addition, if there is material that has not been understood, students can re-access the necessary materials. The utilization of modules in learning places the teacher as a facilitator instead of dominating learning (Ismiyanti et al., 2023). Thus, learning is no longer teacher-centered, but dominated by the active role of students (Sukma et al., 2022).

This digital science teaching material is equipped with a virtual lab, so that students can carry out practicum independently anytime and anywhere. The use of virtual lab-based digital teaching materials makes a positive contribution to the success of physics learning. (Amadeu & Leal, 2013); Virtual lab experiences and computer-based visualizations allow students to interact with scientific concepts that are difficult to observe directly. (Chiu dkk., 2015); it makes learning engaging and allows students to actively manipulate graphical visualizations of complex phenomena (Moser dkk., 2017); and provides opportunities for students to plan, organize, and control learning with a high degree of flexibility. (Arista & Kuswanto, 2018). Modeling and simulation of laboratory experiments can help students overcome cost (Ahmed & Hasegawa, 2014), time, and security obstacles (Kurniawati & Fatisa, 2016). Through interviews, students think positively about their experience in virtual lab-based learning (Aşıksoy & Islek, 2017).

## CONCLUSION

The science digital teaching materials were developed based on the Lee & Owens development model which consists of four stages, namely (1) multimedia need assessment and analysis, (2) multimedia instructional design, (3) multimedia development and implementation and (4) multimedia evaluation. Digital science teaching materials are proven to be very valid for use in learning related to electricity material. The results of media validation showed a percentage score of 92.33% with a very valid category. Based on the media readability test, science digital teaching materials have a readability test score of 83.2%. Thus, digital science teaching materials based on Problem Based Learning on electricity material are very feasible to use in learning for PGMI students at UIN Maulana Malik Ibrahim Malang. Furthermore, it is hoped that this digital teaching material can be developed on other science materials, so that it can be used as the main teaching material in science-laden courses in the Madrasah Ibtidaiyah Teacher Education study program.

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