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[Research Article]

Implementing Scientific Inquiry Learning in Rural Areas: Understanding Students' Needs to Train Inquiry Skills in Dynamic Electricity

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ABSTRACT

The development of digital technology has become a phenomenon that not only changes how we interact with the world but also creates social segregation affecting both advanced and underdeveloped countries, as well as rural and remote areas. The COVID-19 pandemic has accelerated digital adaptation worldwide, emphasizing the importance of digital literacy. To compensate for this situation, ADDIE development research was conducted to address the needs of students. First, the research conducted an analytical survey of 400 middle school students to explore their scientific interests and digital literacy in the Lebak Regency, which had previously been identified as one of the underdeveloped areas in Indonesia but had shed that status in 2019. The analysis revealed that 99% of students had used electronic devices daily. However, only 69% of students used them in an educational context within the classroom. Additionally, the analysis showed that 62% of respondents spent 1-2 hours per day learning activities online, while 30% reported spending more than 6 hours for purposes other than studying. Perceptions of science also indicated high interest (56%), but confusion about concepts still occurred in the classroom, leading to 55% of students not fully understanding the material after completing the class. The research attempted to design web-based learning media as modules to address these challenges. The resulting design was implemented using Google Sites in the form of inquiry-based activities accessible through www.belajarinkuiri.com. In conclusion, the development of web-based e-modules proved to be an effective method to meet the needs of students in the Lebak Regency, Banten, and is worthy of experimentation in the implementation phase. Thus, efforts to address digital literacy challenges and enhance scientific literacy in the era of globalization can be tackled.

Keywords: ADDIE, Guided Inquiry, Scientific Inquiry

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1. INTRODUCTION

The continuous and widespread technological advancements in the 21st century have influenced various aspects of life, including the field of education (BSNP, 2020), and also provided significant benefits in facilitating and bridging the constraints of space and time (Novitasari et al., 2022), as well as played a crucial role in determining the speed and success of knowledge dissemination (Putra et al., 2021). The Global Education Census 2018 conducted by Cambridge International revealed that Indonesian students are the highest users of technology in the world regarding education. The data indicates that 67% of Indonesian students use smartphones for learning, and more than 81% for homework (UCLES, 2018). This number has continued to increase with the global disruption caused by COVID-19, which also allowed educators to explore online learning and the potential of technology, becoming a valuable teaching tool during the pandemic (Field, 2022). Data from the Central Statistics Agency of Indonesia (Badan Pusat Statistic called BPS) also shows a similar trend: from 2016 to 2020, the use of the Internet for learning activities among students aged 5-24 continued to rise. BPS explains that the Internet has become a necessity for students to continue their learning activities amidst the COVID-19 pandemic, in addition to serving as a source of entertainment and information access (Jayani, 2021).

The trends in Indonesia regarding the use of technology in education are also supported by local facts related to technology usage in schools, as determined through a needs analysis conducted with middle school students in the target participant area of this research. Based on observations of 400 students (161 from Grade VII, 120 from Grade VIII, and 119 from Grade IX), it can be concluded that 278 out of 400 students have used electronic devices in the learning process in the classroom. Regarding internet usage, 62% of the respondents stated that they spend 1 to 2 hours per day on self-directed learning activities, while 30% reported spending more than 6 hours on purposes other than studying. Several implications can be drawn based on the data presented in numerous surveys and the results of the author's analysis. Middle school students have had significant exposure to the electronic world, but their usage is not yet optimized. Therefore, students need continuous guidance to balance their internet usage between play and learning. As technology continues to advance rapidly in education, teachers are required to transfer knowledge while adapting their teaching methods and approaches to the technological era.

Character building in the digital era must be adjusted to technological advancements so that learners can adapt to the changing times. However, in their role as shapers of personality, schools often face limitations in utilizing cutting-edge technology, resulting in classroom learning being more lecture-dominated rather than effectively incorporating experimental methods (Tirtarahardja, 2012). Learning through experimental methods directs learners toward concrete experiences and discussions with peers, which leads to the generation of new ideas and concepts (Hayat & Anggraeni, 2011), which is particularly important in subjects like Physics within the science field, which require hands-on experiments to convey abstract concepts. Physics learning should not be limited to reading textbooks but should involve interactions with the natural world through experimentation and practical work to continuously test the scientific validity of the theories (Suparno, 2005).

Furthermore, Physics should be seen not only as a product but also as a scientific process that requires discovering information through students' experiences (Prasetyo, 2001). It is this process of discovering information through experiences that researchers are familiar with as the inquiry process.

Inquiry-based learning is a student-centered instructional model where the teacher acts as a facilitator to develop students' abilities to discover and investigate problems systematically, critically, logically, and analytically based on their innate curiosity, much like a scientist (Margunayasa et al., 2019). Student-led inquiry is considered practice inquiry, distinct from a scientist's work that

aims to nurture scientific work skills rather than produce findings (Widodo & Iriany, 2021). This learning model demands active student participation in problem-solving based on inquiry stages (Artayasa et al., 2017). Inquiry has advantages, including developing self-concept, shaping intuitive thinking, and allowing students to express themselves in the investigative process (Roestiyah, 2012). Another advantage of the guided inquiry learning model is that it allows students to express their ideas and thought patterns in problem-solving, which enhances their self-confidence as they feel valued in the learning process. This, in turn, reduces instances of cheating among students and boosts their self-belief in their abilities (Nur'Azizah et al., 2016).

In addition, to support inquiry-based learning, there is a need for innovation in digital-era teaching to facilitate teachers in delivering easy and enjoyable material for students. Typically, textbooks only present material in text form, with occasional illustrations in certain sections. As a result, not all topics can be visualized by students. To address this issue, electronic modules serve as a solution, where teachers can provide students with interactive electronic modules that include images and animated videos to facilitate material visualization, making even challenging subjects understandable for students (Yuliana et al., 2023). There are many benefits to be gained from implementing web-based digital learning, such as improving the effectiveness and flexibility of learning (Suarsana & Mahayukti, 2013). Electronic modules (e-Modules) are digital versions of printed modules (Sugihartini & Jayanta, 2017), which are systematically organized into specific learning units and presented in electronic format (Yayang & Eldarni, 2019).

Based on the background information provided, this research is interested in researching the development of web-based e-modules for inquiry skills and conceptual understanding of electrical topics. Given the research problem formulated above, the researcher can structure research questions which "What are the characteristics of the web-based e-module developed using Google Site based on the stages of product development, and whether the e-module meets the requirements and suitability for 9th-grade middle school science instruction on electrical topics to be implemented?"

2. METHODOLOGY

This research employs the Instructional Design Method (Campbell, 2014) using the ADDIE model (Analyze, Design, Develop, Implement, and Evaluate) approach to integrate new technology (i.e., Web-Based E-Module Assisted by Google Site) into the classroom. There has been much debate since the 1970s regarding whether instructional design and development is a craft, art, science, technology, or a combination of them all; more precisely, it is a scientific approach. Therefore, the most critical aspect of instructional Design focuses on planning effective learning and suggests that teachers do so before entering the classroom (Flouris, 1988). Furthermore, using instructional design theories like ADDIE helps educators increase efficiency and coherence in the planning and learning process based on the needs of students and teachers (Campbell, 2014).

Instructional Design is commonly used to integrate technology into the classroom. For example, Virtual Reality is designed for collaborative exploration and enhanced creativity (Lee et al., 2021). As Reinbold (2013) expressed, implementing ADDIE can result in instruction that focuses on relevant learning outcomes for students, meets students' needs, and facilitates active learning. Therefore, adapting instructional design is essential for teachers in designing various subjects in the classroom. Maksum (2012) stated that this product could be interpreted as hardware or software, such as interactive learning models, guidance models, and so on (p. 79). This type of research aligns with the research goal of developing web-based inquiry modules.

The ADDIE model was first developed by Florida State University in 1975 as part of a military training project for the United States Army. The early researchers initially defined the model as "the formulation of an instructional systems development program for

military training that will adequately train individuals to perform a specific job and that can also be applied to curriculum development activities." Today, the ADDIE model maintains its five-step approach, allowing teachers to plan courses or curricula using a repetitive, reflective, and streamlined process (Cuofano, 2023).

2.1 Demographic Backgrounds

Demographically, Lebak Regency is considered one of the underdeveloped areas in Indonesia (Otok et al., 2018; Purwanto & Utami, 2023), which was declared away from underdeveloped status in 2019. However, COVID-19 impacted Indonesia's development in early 2020, and the World Health Organization (WHO) announced that the pandemic ended in 2023. It is interesting to discuss the extent of technological transformation implemented in the region. Thus, this place becomes the target participant of this research.

Human resources equipped with knowledge and technology are needed to progress and undergo rapid development, transforming the region from its agricultural base toward industrialization. Bayah is one of the areas in Lebak that hosts large-scale factories producing construction materials that have been operating since around 2018. As a result, making science education a fundamental subject in schools around this area can begin to align with Bayah's transformation into an industrial area, which requires a significant pool of scientific talent. To compete in the modern world, students in Lebak must have a thorough grasp of science and technology.

2.2 Questionnaire

The questionnaire consists of several instruments to assess various conditions used as the primary data collection tools, including two main sections. The first questionnaire is the needs analysis questionnaire, which consists of two interconnected parts, as seen in Appendix A, including (1) questions related to the extent to which they adopt technology and apply it in education and (2) students' opinions regarding their preferences and concerns about the science subjects in middle school. The second questionnaire is about the perception of the inquiry experience, adapted from Spronken-Smith et al. (2008), which is used to assess participants' responses to the learning experience. The perception of the inquiry experience consists of two parts: (1) motivation to engage in learning activities, which includes 7 questions, and (2) students' experiences in learning, which comprises 10 items.

2.3 Conceptual Understanding

Pretests and posttests are administered before and after the inquiry learning task. These tests assess participants' knowledge and understanding of electrical circuit concepts. Each test consists of 10 multiple-choice questions that evaluate the understanding of dynamic electricity, including (a) electric charge, (b) electrical resistance, (c) current, (d) open and closed circuits, and (e) series and parallel circuits. For example, a question related to brightness proportionality might be: "Three light bulbs are connected in a parallel circuit. Then, students are asked to observe what happens when the switch is closed", as shown in Figure 1.

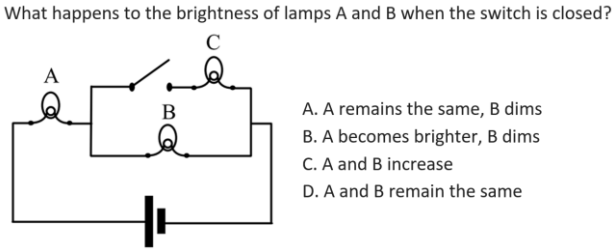

Figure 1. Serial Parallel Circuit Questions for conceptual understanding of Electrical Circuit Concepts.

Additionally, students' perception of inquiry learning will be tested using the attitude aspect component, which involves participants' responses to the adopted inquiry experience as adapted from Spronken-Smith et al. (2008) before and after the learning.

2.4 Inquiry Task

Participants were given three main investigative tasks. They started with understanding electric charge and were later asked to delve into the components within the simulation, create series and parallel circuits,

and use measuring instruments to understand the relationship between voltage and current. They were then tasked with making predictions about a circuit's current, voltage, and bulb brightness by configuring various components to investigate their predictions. Participants received a web-based inquiry task assessment e-module and could refer to it freely during the experiment. The web-based e-module was developed following the guided inquiry learning stages adopted by Widodo and Iriany (2021).

Each participant conducted scientific investigations following the inquiry learning stages and used the Circuit Construction Kit: DC (PhET) during the data collection stage to explore electrical concepts through experiments on series and parallel circuit simulations (Figure 2). The simulation was equipped with electronic components and instruments to measure voltage and current, allowing participants to configure both series and parallel circuits.

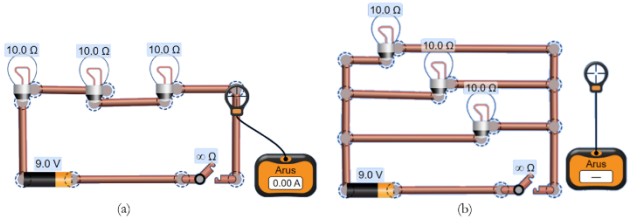

Figure 2. Screenshots of the simulation environment (a) series and (b) parallel (PhET, University of Colorado Boulder https://phet.colorado.edu).

3. RESULTS AND DISCUSSION

3.1 Analyzing

The needs analysis survey was conducted in Lebak Regency, Banten Province, which is relatively close, only 150 kilometers from the Ministry of Education Headquarters. This survey assessed how closely the government's efforts to promote digital education and literacy have been achieved in the immediate vicinity, and this research aimed to determine its realization. In this study, the participants were junior high school students in Lebak. In total, 400 students filled out the questionnaire. The field observation survey included 161 seventh-grade students, 120 eighth-grade students, and 119 ninth-grade students.

Regarding digital literacy, the survey found that 396 students have electronic devices at home (Smartphones, Laptops, and Computers), while only 4 students do not own any. Additionally, the analysis related to the use of technology in learning was relatively high, with 69% of students expressing that they have used it in the classroom and only 31% have not (Figure 3a). However, in terms of technology use in learning, 66% of students indicated that they sometimes face challenges when using digital devices, while only 10% of students reported no issues with their usage (Figure 3b).

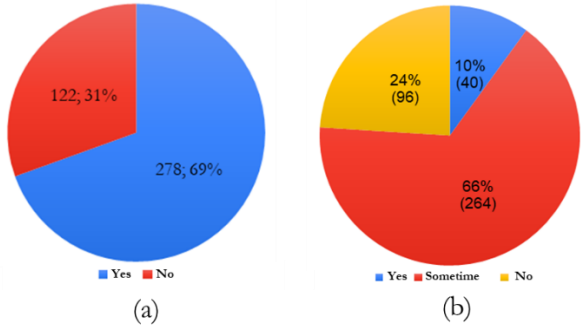

Figure 3. Diagram (a) illustrates the use of technology in learning, and (b) shows the challenges in learning using digital devices.

Additionally, field analysis shows that only 61.75% of smartphone users spend 1 to 2 hours studying using their devices, while 18.25% of students use their devices for 2 to 4 hours, 4.5% use their devices for 4 to 6 hours, and only 3.5% use their devices for more than 6 hours. Also, 12% of students never use their devices for studying. From the perspective of study time, these figures are considered quite good for using electronic media for learning. On the other hand, the use of smartphones for activities other than studying is much higher. 18.75% of students use their devices for 1 to 2 hours, 27.25% use their devices for 2 to 4 hours, 21.75% for 4 to 6 hours, and 29% for more than 6 hours. Only 3.25% of students never use their devices for purposes other than studying (Figure 4).

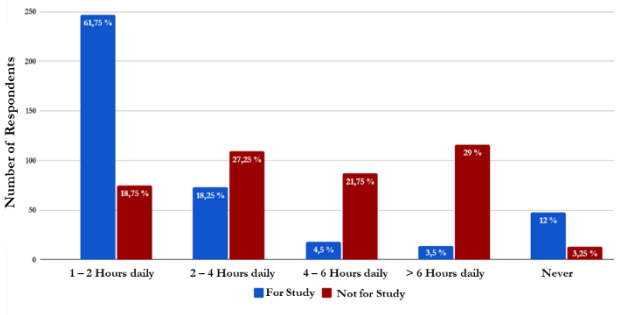

Figure 4. Utilization of Smartphones by Students.

From the comparison of both survey data, the use of smartphones for learning purposes is still significantly lower than for other activities (social media and games). Therefore, optimizing smartphones and other devices for learning needs to be enhanced. Students should use them for purposes other than learning and use them more effectively and productively to compete in the digital world.

In addition to the technology-related survey, a survey related to students' perceptions of science class learning was also conducted to gain a more comprehensive understanding of students' learning experiences and how technology influences their perception of learning. The results of this survey are expected to provide insights into the development of science teaching methods in this research, to enhance students' interest and understanding of the subject. Furthermore, the researcher uses data from this survey to design more effective and relevant development media and strategies that align with the student's needs at the school.

Table 1. The results of the needs analysis related to the perception of science class learning in the classroom.

No	Questionnaire	n	%
1.	**Tendency to like science lessons**		
	Not like it	7	2%
	A little like it	167	42%
	Like it	226	56%
2.	**Perception of science lessons**		
	Difficult to understand	82	21%
	Sometimes easy to understand	233	58%
	Easy to understand	85	21%
3.	**Common difficulties encountered in learning science subjects**		
	The material presented is difficult to understand and not concise	210	52%
	The textbook is in English	42	10%
	The material explanation is monotonous and boring	58	15%
	Others: • Not understanding the logic of formulas and then finding it difficult to comprehend	39	9.75%
	• Teacher's incompetence	5	1.25%
	• Unclear explanations from the teacher	1	0.25%
	• Personal health	3	0.75%
	• Difficulty in calculations	17	4.25%
	• Taking too many notes	4	1%
	• The questions and the learning material are different	3	0.75%
	• The material is too summarized	2	0.5%
	• Difficult to memorize	2	0.5%
	• Understanding when the teacher explains in detail	2	0.5%
4.	**Understanding of science material after completing the science lesson**		
	Do not understand	9	2%
	Do not understand well	219	55%

No	Questionnaire	n	%
	Yes, understand	172	43%
5.	**Tendency to like science learning presented using specific strategies**		
	Only using textbooks from school	118	30%
	Using digital learning media.	120	30%
	Practicum or experiments.	141	35%
	Others: • Explained directly by the teacher.	17	4%
	• Storytelling	2	0.5%
	• Whiteboard	1	0.25%
	• Learning while going on a study tour.	1	0.25%

From Table 1, many interesting insights can serve as a reference for designing instructional media. The data in this table can be a crucial basis for identifying trends or student preferences regarding the most effective and engaging instructional media in the context of science learning. Some key points that the researcher has noted and used as a reference for further development include students tending to like science lessons (56% of students) and somewhat like them (42% of students), although the majority of students (55%) admit to having a limited understanding of science material after completing the lessons.

In terms of students' positive perception of science, it may be influenced by societal changes. Science education is increasingly essential in line with societal changes towards modernization, as science and technology are closely related to a nation's development level. In the early stages of industrialization, the focus was on progress, growth, and national development. Consequently, science and technology are seen as vital for society and meaningful for individuals. In contrast, in some advanced countries that have already passed the era where the roles of physicists, technicians, and engineers are considered necessary for people's lives and the nation's prosperity, young people in poorer and developing countries have a heroic image as scientists, a phenomenon not seen in highly developed Western societies (Sjøberg & Schreiner, 2005).

Additionally, increasing science education is often a priority in developing countries to promote long-term economic development. Therefore, many initiatives, both government-sponsored and foreign-aided, aim to enhance science education in developing countries (Rogan & Grayson, 2003). In conclusion, students in Lebak have perceptions similar to those observed in other studies (Rogan & Grayson, 2003; Sjøberg & Schreiner, 2005), and teachers should support these perceptions to maximize their motivation.

Another essential point is that students tend to like learning through digital learning media (30% of students) and experiments or practical work (35% of students). However, in practice, many students also expressed that they need a teacher as a facilitator and rely on their teachers for understanding. For example, some students indicated that they like science lessons explained directly by the teacher (4%), and they faced challenges when teachers did not explain the subject in detail (0.5%), when the teacher lacked competence (1.25%), or when the teacher's explanations were unclear (0.25%). Therefore, in designing the teaching strategy in this research, guided inquiry is applied so that students can explore freely while being guided by the educator at the same time.

3.2 Designing

In designing digital learning media, guided inquiry is used as a reference for the teaching strategy. Inquiry has different levels of complexity in its application: structured inquiry, guided inquiry, open inquiry, and the learning cycle. Unlike open inquiry, which is similar to how researchers work and is free from teacher intervention, guided inquiry involves the teacher providing materials and formulating research problems while students design the research procedures to find answers to the problems (Colburn, 2000). The developed web-based e-module follows the stages of guided inquiry learning as adopted from Widodo and Iriany (2021), which include formulating a problem, formulating a hypothesis, designing an investigation, conducting an investigation, data collection and analysis, and drawing conclusions (Figure 5). Ayu et al. (2022) have also conducted the design of the Physics E-Module in creating a Webtoon-based Physics E-Module to enhance critical thinking skills.

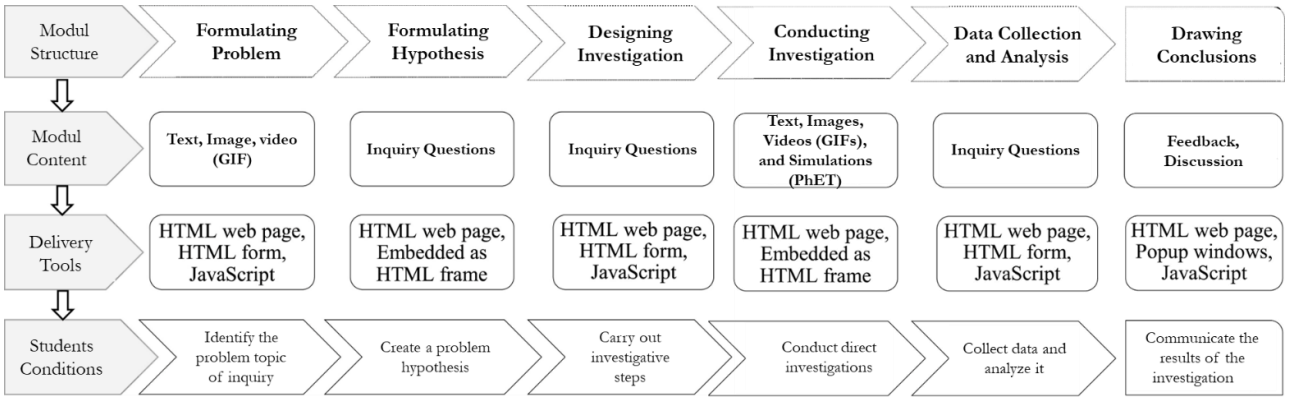

Figure 5. The design of the media developed follows guided inquiry learning.

Furthermore, the physics concept used in this research is electricity, precisely dynamic electricity, closely related to daily life. The reason for choosing the topic of dynamic electricity in this research is, first, because this topic is considered difficult for students during learning. The material is abstract and cannot be seen directly, but its benefits are felt daily, especially in motorcycle electrical engineering, household electricity, and electronic equipment. Many students, even graduate students, have misconceptions about basic electrical concepts, and many of these students, who have completed their coursework with high grades, fail to answer basic conceptual questions in the field (Finkelstein, 2005). Second, considering the Basic Competencies (Kompetensi Dasar called KD) in the topic of dynamic electricity, which include applying the concept of electrical circuits, electrical energy, and power, electrical energy sources in daily life, including alternative electrical energy sources, as well as various efforts to save electrical energy, students' understanding and application in solving Physics problems, especially for junior high school students, can be improved.

3.3 Developing

In the development, the Google Sites platform creates web-based inquiry activities accessible via https://www.belajarinkuiri.com (Appendix C). In addition to the developed media, a lesson plan is also included to serve as a guide for implementing the learning activities (Appendix D). The developed media consists of several key components, including the interface component (Figure 6a), learning objectives (Figure 6b), problem formulation (Figure 6c), and data collection pages (Figure 6d).

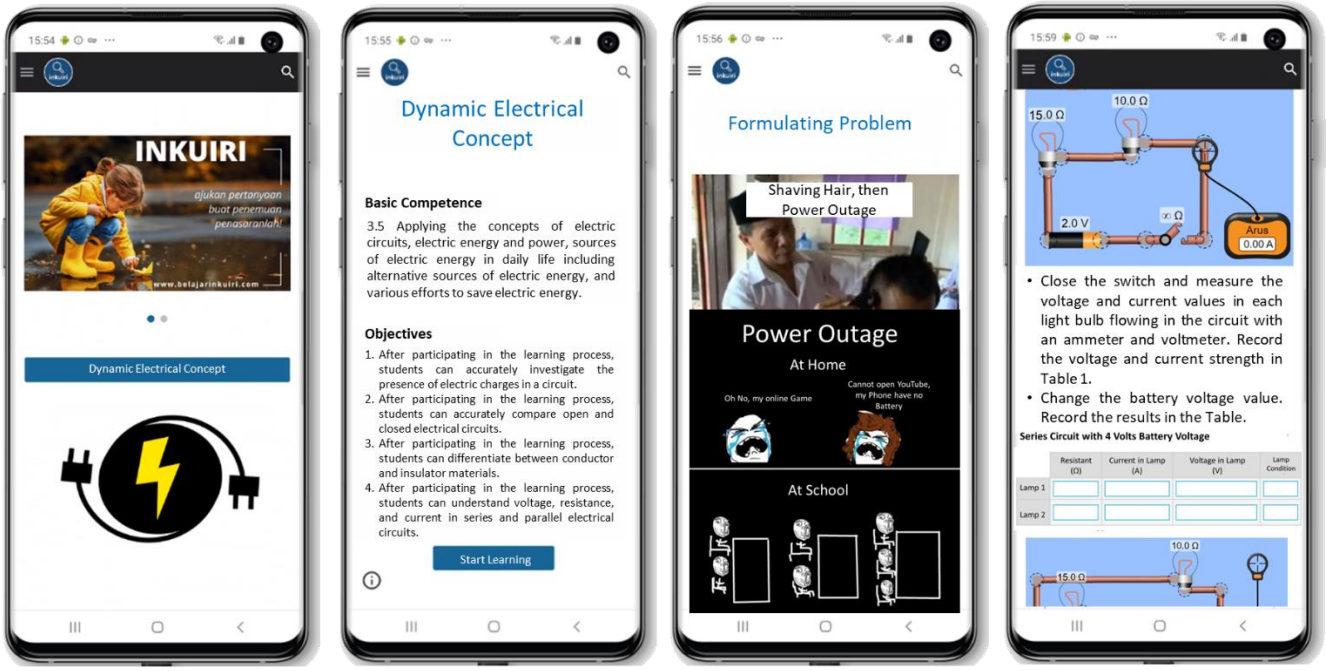

Figure 6. Screenshots of the developed media include (a) the interface page, (b) learning objectives, (c) problem formulation, and (d) data collection pages.

Furthermore, Storyboarding is an essential step in visualizing the user experience within an application. It is a critical process in software development that helps the development and design teams depict how the application will function and how users will interact with its elements. The primary purpose of creating a storyboard is to communicate the application's vision to all parties involved in development, including developers, designers, stakeholders, and potential users. This ensures that everyone consistently understands the application's goals and concepts, as depicted in Figure 7.

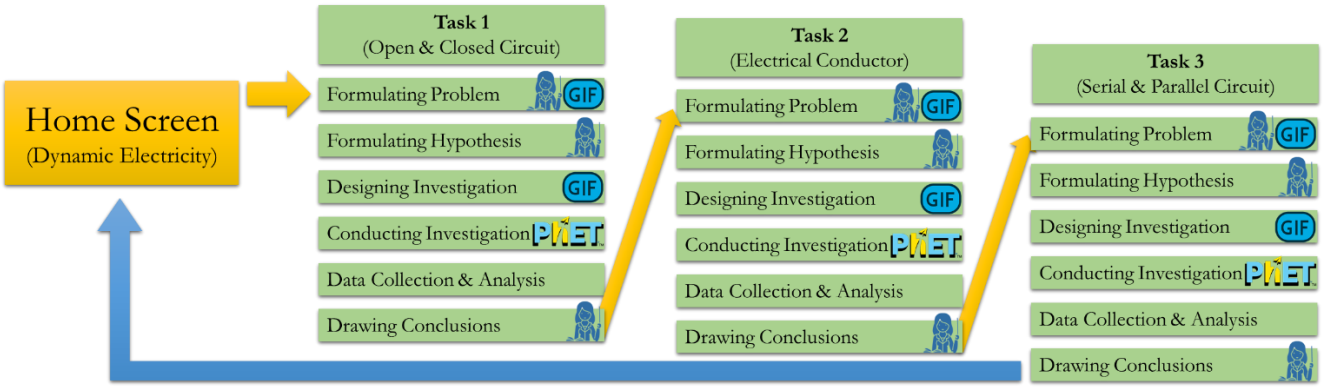

Figure 7. Storyboard for the developed media.

The storyboard in Figure 7 explains that in the Dynamic Electricity material, two activities are carried out, namely open and closed circuits, electrical conductors, and series and parallel circuits. They all follow the same pattern in presenting digital content in their stages, such as problem formulation presented with GIF animations with guidance from the teacher to formulate and trace the problems that occur during the activities. Then, the formulation of hypotheses and conclusions that require the teacher's involvement, and some components done by students alone, such as conducting investigations using PhET® simulations.

4. CONCLUSION

Indonesia's digital adaptation has been challenged by COVID-19, which has required the widespread adoption of technology by the population. Similar to some students in Brazil and the United States who have fallen behind due to a lack of access to computers and the Internet, certain regions in Indonesia that lack access to adequate infrastructure have suffered significantly because of COVID-19. This includes remote areas without access to necessities like electricity. Nevertheless, digital inequality and disparity have increased when some people lack the necessary devices or training to adapt or don't have internet access (Bakker & Wagner, 2020). This highlights the importance of pragmatic solutions to digital literacy in this era of globalization through the design of digitized learning.

From the analysis phase (Analyze) results within the ADDIE model, the level of technology adaptation is relatively high, even though its usage is not in the field of education. Moreover, from a science perspective, students' motivation and interest in science are relatively high, indicating societal development and transformation toward modernity. Subsequently, the analysis results are applied to the design phase (Design) of media development, and it is indicated that digital media in the form of a web-based module is an adequate design to meet the needs of the target participants in the area. In the development phase (Develop), the Google Sites platform creates a web-based inquiry activity accessible through www.belajarinkuiri.com.

In conclusion, developing this web-based e-module is an effective method to address the needs of students in Lebak Regency, Banten, and is worthy of being tested on an implementation scale.

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