Jurnal Penelitian Pembelajaran Fisika
Vol. 16 Issue 4 – October 2025, p384-392
p-ISSN 2086-2407, e-ISSN 2549-886X
Available Online at http://journal2.upgris.ac.id/index.php/JP2F
DOI: 10.26877/jp2f.v16i4.2717

Development of E-Worksheets Discovery Learning Model Assisted by Augmented Reality for Renewable Energy Topic

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Received: 20 September 2025. Accepted: 26 October 2025. Published: 30 October 2025.

Abstract. The poor motivation and interest of students in learning physics which is frequently viewed as challenging and less interesting led to the conduct of this study. As a result, creating cutting-edge educational materials that may facilitate interactive learning and foster a deeper conceptual grasp is essential. Building an Electronic Student Worksheet on the subject of renewable energy using the Discovery Learning methodology enhanced by Augmented Reality is the aim of this study. The research and development (R&D) method for this study was conducted Subject matter and media experts validated the generated product, and teachers and high school students participated in restricted trials to verify its viability and usefulness. The findings show that professionals rated the Worksheet as highly valid, and both teachers and students found it to be very interesting and user-friendly. Therefore, it is possible to implement the Augmented Reality assisted Discovery Learning-based Worksheet in physics education, and it has the potential to improve students' engagement and comprehension of renewable energy ideas.

Keywords: e-worksheets, discovery learning, augmented reality

1. Introduction

Renewable energy is increasingly becoming a major focus in education worldwide [1],[2]. As climate change and the need for sustainable energy sources become increasingly recognized, renewable energy topics need to be taught effectively to students [2], as education must evolve to equip future generations with the knowledge and skills to face the complex challenges of nature [3],[5].

The use of digital media as a teaching aid is a new trend [4] . Technology-based learning materials have the ability to increase student engagement and make the material easier to absorb [5]. In addition, the use of technology-based learning materials increases student engagement and facilitates the visualization of abstract ideas so that they are easier to understand. [8]. According to interviews with physics teachers at SMAN 15 and SMA Persada Bandar Lampung, students still often use traditional media, such as textbooks and PowerPoint presentations, in their learning. The learning models used still use conventional approaches such as lectures, experiments, and discussions, even though technological facilities such as projectors are available, the use of technology in learning media is still not optimal. [9] This situation shows the need for more interactive and varied media to increase students' interest in learning, especially in physics subjects.

Therefore, before learning activities take place, educators are required to prepare learning plans, learning strategies, and supporting tools such as teaching materials, teaching modules, and teaching media [10]. Teaching materials themselves for educators function as a tool designed to facilitate the delivery of material [11]. Meanwhile, for students, they can increase participation, enthusiasm for learning, and learning [12]. Because they can encourage and build an active and independent learning process, Student Worksheets (LKPD), one of the most popular learning resources, help support

teaching and learning activities [13]. LKPD can be presented in two forms, Printout and electronic. Worksheet is an innovation in the development of teaching materials [14], which offers flexibility and efficiency in learning [15]. Furthermore, Worksheet has great potential when integrated with the Discoveri Learning learning model, because it can facilitate students in exploring problems, discovering concepts independently, and building deeper understanding through active and contextual learning experiences.

Discovery Learning methodology itself gives students the ability to actively investigate and discover the concepts being taught, instead of passively gathering knowledge [16]. In the context of physics learning, this strategy is very effective because it allows students to understand renewable energy topics through exploration and investigation. Augmented Reality (AR) technology can be used to further enhance the integration of Worksheet with Discovery Learning methodology[17]. Real-time display of 2D or 3D visual items is possible with augmented reality [18].

This study differs from previous studies because it uses electronic e-worksheets combined with augmented reality capabilities within a Discovery Learning framework for renewable energy content. Several previous studies have indeed integrated AR into electronic media, but in different contexts or learning models. For example, Saputra and Octavia created an AR-assisted e-module on biology (viruses) based on Discovery Learning, which proved to be quite practical and successful. [19]. Similarly, Utami et al. created an AR-assisted Worksheet on chemical bonds using Problem-Based Learning techniques. Experts considered it feasible, and students responded positively to it [20]. However, the two studies had different contexts, one in biology and one in chemistry and used a model other than Discovery.

In addition, [21] developed an AR-assisted contextual renewable energy module integrated with Al-Qur'an values, and the module was reported to be valid and very practical for teachers and students. Their approach focused on the integration of religious context and contextual teaching module, while [22] emphasized the application of Problem Based Learning, while our research prioritized the Discovery Learning model in the Worksheet format on the topic of renewable energy physics. Thus, the novelty of our research lies in the synergy of AR and Discovery Learning in Worksheet for renewable energy material, a combination that has not been widely studied before.

2. Method

This research uses research and development methodology. Sugiyono defines R&D as a research methodology that aims to develop a particular product and assess its efficacy. [23]. The development paradigm used is the ADDIE approach, which consists of 5 stages: analysis, design, development, implementation, and evaluation [24]. The advantage of the ADDIE model lies in the evaluation process at each stage, so that it can minimize errors and product deficiencies in the final stage of development [25].

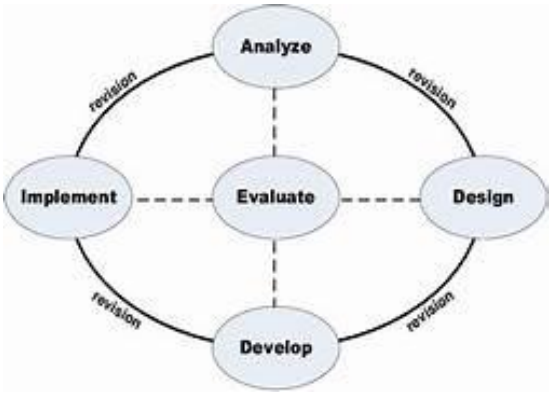

Figure 1. *ADDIE research step [23].*

Below are the stages of developing AR-assisted Worksheet Discovery Learning in this study: Analysis: To determine learning needs and problems, observations were conducted at SMAN 15 Bandar Lampung

& SMA Persada Bandar Lampung using questionnaires & interviews. Design: Resource gathering for renewable energy, utilizing Assemblr Edu to create augmented reality, and using Canva to design Worksheet before turning it into a flipbook. Development: To determine feasibility, media and content experts validate the product. Implementation: To evaluate teacher and student responses, small group trials & field trials were conducted. Evaluation: Examining instructor and student comments after using Worksheet.

Validation questionnaires, physics instructor interviews, and response tests are some of the methods used to obtain data. The Likert scale is used for qualitative and quantitative analysis as shown in Table 1.

Table 1. Likert scale validation sheet criteria *[26]*.

Criteria	Score
Very Worthy	5
Worthy	4
Quite Decent	3
Not feasible	2
Totally Unworthy	1

Expert validation was carried out using an instrument in the form of questions answered on a Likert scale. The validation results form the basis for assessing product feasibility. Worksheet evaluation is also carried out through responses from educators and students, which are then analyzed by calculating the overall percentage of respondents' answers using a predetermined formula.

$$P = \frac{\Sigma x}{\Sigma xi} x\ 100\% \quad (1)$$

where P is the percentage of eligibility, Σx is the number of respondents' answers per item, and Σxi is the ideal number of respondents.

3. Results and Discussion

3.1. Result

3.1.1 Analysis Stage

At this stage includes an analysis of existing problems in SMAN 15 and SMA Persada Bandar Lampung as a basis for making Worksheet Discovery Learning model assisted by Augmented Reality . This step includes assessing the needs of educators, students' needs and analyzing the effectiveness of teaching materials, as well as checking learning outcomes (CP), learning objectives (TP), ITP. The results of the analysis found that educators have not been able to activate students through the teaching materials provided and the teaching and learning process tends to use lecture methods and is still centered on the educator. From the results of observations obtained regarding the needs of students, namely students need appropriate, non-monotonous and enjoyable teaching materials.

3.1.2 Design Stage

During the design phase, researchers conducted several activities, including adapting renewable energy materials, designing the E-Worksheet, and developing product feasibility instruments. The product description is as follows:

A. Material Design

Renewable energy material in E-Worksheet is adjusted to the learning outcomes obtained through interviews. In addition, the learning resources produced in E-Worksheet include Augmented Reality QR-Code, simulated image photos, and video materials. An overview of the content contained in the resulting teaching materials is presented below: 1. Discussing various types of energy; 2. Differentiating renewable and non-renewable energy; 3. Practicum. The outline of the content in show in Figure 2.

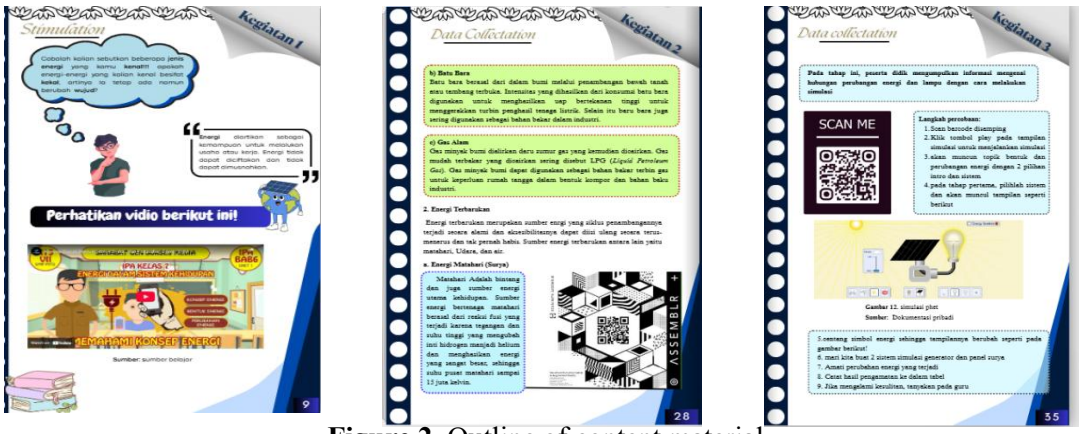

Figure 2. Outline of content material.

B. Augmented Reality Design and E-Worksheet Design

Based on the analysis of the research subjects, an E-LKPD was developed that uses the Discovery Learning model supported by augmented reality. The goal of educational resources developed using the Discovery Learning approach is to place students at the center of the learning process and enable active engagement. In addition, the teaching materials also contain instructions for use, videos, images, 3D animations, and *simulation photos* . For example, for activity 2 there is a 3D animated QR-Code as an illustration of the material as seen in Figure 3. In the E-Worksheet that was designed.

Figure 3. Augmented reality has developed.

Examples of activities in E-LKPD can be seen in **Figure 4.**

Figure 4. Outline of the contents of activities in the product being developed.

C. Product Feasibility Instrument Development

The instrument created in this study was to assess the feasibility of the product. The assessment aspects used by the material experts were: 1. Content Suitability; 2. Language Suitability; 3. Presentation Suitability. It is crucial to ensure that the Learning Outcomes (CP), Learning Objectives (TP), and Learning Target Indicators (ITP) in the learning materials are aligned with each other. Furthermore, it is important to ensure that the presentation is accurate and the language used is appropriate. Students, teachers, media specialists, and content specialists will use this tool.

Aspects such as 1) Graphic Suitability and 2) Assemblr Edu Application Suitability are evaluated by media professionals. In order for students to feel comfortable and understand the content delivered through the teaching materials that have been created, it is important to pay attention to these factors during the presentation.

Finally, field trials and small group trials were used as instruments.

using several aspects; 1). Appearance; 2). Material; 3). Language; 4). Interest; 5). Discovery Learning. Educators as learning actors in the classroom can consider the content and appearance in the classroom and can also assess the effectiveness of the use of the teaching materials they have developed.

3.1.3 Development Stage

At this stage, the developed product was put into practice through expert validation testing, conducted by three validators: three media experts and three content experts. After evaluation, the teaching materials were approved for field trials.

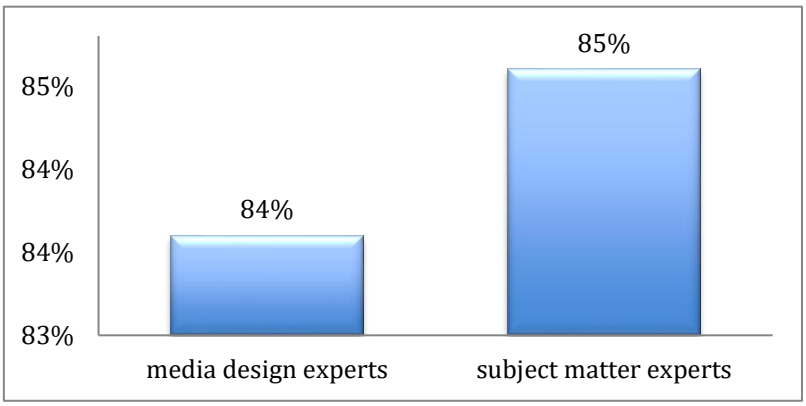

Figure 5. Percentage of expert assessments.

Based on the graph in Figure 5, the media validation teaching material received a percentage score of 84%, or "Very Appropriate". The percentage value of 85% was obtained through validation by material specialists, which meets the criteria of "Highly Appropriate".

3.1.4 Implementation Stage

A. Small Group Trial

A small-group trial was conducted on 10 students from SMA Persada Bandar Lampung and SMAN 15 Bandar Lampung. To identify initial issues with the E-LKPD, a sample of student responses was taken from this trial. The results of the small-group study are shown in Table 2.

Based on the results of small group trials at SMAN 15 Bandar Lampung and SMA Persada Bandar Lampung in Table 2, 91% of the assessments were considered "very interesting" for the Discovery Learning aspect, 90% for the language aspect, 83% for the interest aspect, and 85% for the appearance aspect. The "very interesting" category has a percentage value of 85% for the material aspect. Based on the average percentage results from the small group trial stage on the resulting E-LKPD, a final percentage value of 87% was obtained in the "very interesting" category.

Table 2. Small group assessment results.

NO	Assessment Aspects	Percentage	Category
1.	Appearance	85%	Very interesting
2.	Material	85%	Very interesting
3.	Language	90%	Very interesting
4.	Interest	83%	Very interesting
5.	*Discovery Learning*	91%	Very interesting
	Average Amount All Aspects	87%	Very interesting

B. Field Trial

a. Educator Response

Table 3 below displays the findings of physics subject educators' responses to the E-Worksheet that was created:

Table 3. Results of the field test assessment of educator responses.

NO	Assessment Aspects	Percentage	Category
1.	Attraction	85%	Very Worthy
2.	Material	85%	Very Worthy
3.	Language	85%	Very Worthy
4.	Presentation Techniques	88%	Very Worthy
Average		86%	Very Worthy

Based on Table 3, the results of the teacher response test at SMAN 15 and SMA Persada Bandar Lampung show that the attractiveness aspect obtained a percentage of 85%, the material aspect 85%, the language aspect 85%, and the presentation technique aspect 88%. The average for these four aspects reached 86%, which is included in the "very appropriate" category.

b. Student Response

Table 4 displays the results obtained from the questionnaire distribution. This study involved 64 students from two schools, SMAN 15 Bandar Lampung and SMA Persada Bandar Lampung, on a larger scale.

Table 4. Results of student field test assessment.

NO	Assessment Aspects	Percentage	Category
1.	Appearance	84%	Very interesting
2.	Material	84%	Very interesting
3.	Language	84%	Very interesting
4.	Interest	83%	Very interesting
5.	*Discovery Learning*	79%	Interesting
	Average Total Aspects	83%	Very interesting

The findings of an experiment involving 64 students at SMAN 15 and SMA Persada Bandar Lampung are shown in Table 4. The appearance, material, and language components each scored 84% in the "very interesting" category. The Discovery Learning component scored 79% in the "interesting" category, while the interest component scored 83% in the "very interesting" category. These five factors combined averaged 83%, which falls into the "very interesting" category.

3.1.5 Evaluation Stage

To determine the strengths and weaknesses of the design and development process from beginning to end in the ADDIE model, an assessment stage was conducted at each stage. Based on the results of the research evaluation, the resulting E -LKPD was very interesting and practical, and both

teachers and students gave positive reviews. The development of an Augmented Reality (AR)-based E -LKPD product that utilizes the Discovery Learning methodology for renewable energy is a real example. This proves that the resulting E -LKPD product is very interesting and practical, so it can be said to be completed, complete, and usable.

3.2. Discussion

In an effort to keep up with the times, digital media has been developed as a teaching aid [6]. Technology-based learning materials have the ability to increase student engagement and make the subject matter easier to understand [7]. This project uses the Discovery Learning methodology to produce E-Worksheet teaching materials on renewable energy with the help of augmented reality. Based on expert evaluation, field trials, and effectiveness analysis, it can be said that E-Worksheet is very suitable for use in learning. These results are in line with previous research that used Worksheet and augmented reality as teaching aids [27],[28],[29],[30].

This study also found that the Augmented Reality-assisted E-Worksheet teaching materials were highly appealing and a valuable learning media innovation. This can be seen in Table 4 , which shows that of the 64 students who used the E-Worksheet, most stated that the teaching materials were very engaging. Physics teachers from two schools also stated that the Augmented Reality-assisted E-Worksheet was highly suitable for use. Thus, it can be said that E-Worksheet with Augmented Reality support is a worthy choice for physics learning in the classroom.

E-Worksheet in the Discovery Learning model offers several benefits. First, through individual and group activities, augmented reality-based E-Worksheet can help students understand physics topics and discover new ideas. [31]. In addition, we can form E-Worksheet with the help of Augmented Reality according to the needs of the field and students and this device is flexible and easy for students to access via a smartphone connected to the internet. [28].

Despite its many advantages[32], Augmented Reality-assisted E-Worksheet has several drawbacks. One is its reliance on internet access, which limits its use in low-connectivity environments. Furthermore, producing an Augmented Reality-assisted E-Worksheet takes a considerable amount of time, particularly in terms of constructing the Augmented Reality . The resulting product also only covers one learning topic, renewable energy, so its scope remains limited. Several suggestions for further development can be made based on the research findings. Augmented Reality-assisted E-Worksheet can be expanded to include other physics learning materials, thus broadening its scope of use.

4 Conclusion

The product-like assessment conducted by media experts and research material experts was deemed very appropriate, and the results of instructor and student responses to the E-LKPD were considered very interesting. Thus, it can be said that the creation of E-LKPD using the Discovery Learning model and augmented reality is suitable for use in educational activities. Recommendations for prospective researchers: Further research is needed to refine the product that has been developed and optimize its potential in various materials.

Acknowledgment

The authors would like to express their sincere gratitude to SMA Negeri 15 Bandar Lampung and SMA Persada Bandar Lampung for granting permission and providing support during the research process. The collaboration and cooperation from the teachers and students were invaluable in completing this study successfully.

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