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Solar cell based power-bank prototype as a media to increase students' scientific literacy

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ABSTRACT

This research aims to i) implement the solar cell based power-bank prototype for learning media; ii) describe the feasibility of the solar cell-based power-bank prototype for learning; and iii) describe students' scientific literacy. This research method uses the analysis, design, development, implementation, and evaluation (ADDIE) research and development model. The subjects of this research are class IX students and science teachers at SMPN 4 Central Bengkulu. Data collection techniques include questionnaires, tests, and interviews. The data analysis technique uses N-gain analysis, percentages, and the Aiken's V formula. The research results show that the media developed is valid with an Aiken index value of 0.98 > the minimum standard Aiken' V of 0.92 and can increase students' scientific literacy based on an N-gain of 0.92. 0.71, this can be seen in the dimensions of context and content based on N-gain of 0.73 and 0.69, while the dimensions of attitude, curiosity, respect, and willingness, reflect the respective percentages of 79.62%, 78.86%, 78.89%, 75.60%. Based on the results of the hypothesis test, the sig value is obtained. (2 tailed) 0.000<0.05 which means Ha is accepted and Ho is rejected, which means the solar cell-based renewable energy media used in science learning influences the increase in students' scientific literacy.

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1. INTRODUCTION

Science learning emphasizes direct experience so that students are able to understand what is being studied. Therefore, the use of media is necessary to explain concepts so that students can easily understand the things the teacher puts forward [1]. Media is designed in accordance with the principles of knowledge in the material being discussed, media optimizes the function of students' senses to increase the effectiveness of learning by hearing, seeing, feeling, using thinking logically and realistically [2]. Media makes it easier for students to understand concepts, construct knowledge, foster interest, activity and creativity, and make abstract concepts concrete [3]-[6]. Renewable energy is energy produced by the sun, wind, water, and geothermal energy, which is a context that needs to be taught using media. Learning about renewable energy is ideally carried out with practicums accompanied by media to illustrate renewable energy in everyday life [7], [8]. However, obstacles were encountered in carrying out the practicum, namely that there were still very few learning media in the context of renewable energy available in schools. This is in line with the opinion of

[9], [10] which states that learning about renewable energy in junior high schools is only limited to the knowledge level, not at the practical level. Research on the development of two-axis solar tracker media and Arduino-based solar cells shows that the media can increase student creativity in the medium category, help teachers understand energy to students, increase students' knowledge, attitudes, and behavior towards renewable energy through experience [11]-[16].

Solar cells are devices that can convert sunlight energy into electrical energy through the photovoltaic process. The photovoltaic effect is defined as a phenomenon of the emergence of an electric voltage due to the contact of two electrodes connected to a solid or liquid system when exposed to solar energy. Solar energy or light radiation consists of refracted photons that have different energy levels. The photons absorbed by the PV cells will trigger the generation of electrical energy. The energy produced by the solar module can be directly distributed to the load or stored in the battery before use.

Based on Figure 1 it can be explained that; photons as sunlight particles carrying mc2 energy hit the silicon semiconductor of the solar cell producing energy that can free electrons from its structure. These free electrons come from silicon semiconductors so that atoms lose electrons which create "holes" as positively charged electrons. The part of the silicon semiconductor that is filled with free electrons is negative and functions as an N type semiconductor. Meanwhile, the part of the semiconductor with holes that has positive properties functions as electrons which are accepted as type P. The junction that occurs between type P and type N forms a PN Junction. PN Junction produces energy and is able to push electrons and holes strongly to move in opposite directions, thus producing an electric current.

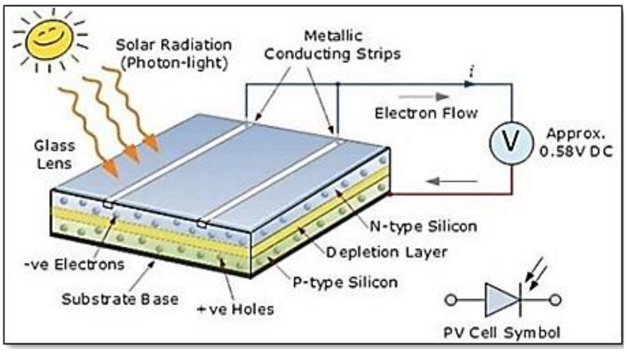

Figure 1. Solar cell structure

- Problems, goals, and solution plans

Based on the results of interviews with science teachers at SMPN 4 Central Bengkulu, it is known that the delivery of renewable energy context material still uses the lecture method, the only media used are textbooks and charts. Teaching aids in the context of renewable energy are not yet available, so the use of science teaching aids is only carried out on certain materials. Therefore, it is necessary to develop science teaching aids as a medium for learning material with a renewable energy context, especially technology for utilizing solar energy using solar cells. Because of this, researchers conducted research on the use of solar energy using solar cells as a learning medium. The title of this research is "Solar cell based power-bank prototype as a media to increase students' scientific literacy". For this reason, the problem is formulated as follows "Is the solar cell based power-bank prototype as a media to increase students' scientific literacy"; i) Can it be implemented?; ii) Suitable for use for learning?; iii) Can it improve students' scientific literacy?.

In order to find a solution to the above problems, research objectives were formulated i) implementing a solar cell based power-bank prototype as a media to increase students' scientific literacy; ii) describe its suitability for learning; iii) describe students' scientific literacy? Therefore, this research was carried out with the following stages/algorithms: i) creating a solar cell based power-bank prototype as a learning media; ii) testing the feasibility of the solar cell based power-bank prototype as a learning media; and iii) describing students' scientific literacy after learning using solar cell based power-bank prototype as a learning media. It is hoped that these findings will increase our insight into the role of the solar cell based power-bank prototype in learning.

2. METHOD

This research uses the ADDIE research and development model method, namely analysis, design, development, implementation and evaluation. The research subjects were 40 students, 3 science teachers at

SMPN 4 Central Bengkulu, and 3 lecturers at FKIP Bengkulu University. Data collection techniques include student questionnaires, tests, expert validation questionnaires and science learning interview guides. The data analysis technique uses qualitative and quantitative descriptive analysis techniques.

2.1. Research stages
2.1.1. Needs analysis
Needs analysis, namely exploring the potential and problems of research subjects, then analyzed and evaluated as a basis for the next stage. Data analysis of student needs questionnaire answers is carried out using (1).

$$P = \sum \frac{X}{N} X100\% \quad (1)$$

Description: P = score percentage, $\sum X$ = total score, and N = maximum score.

2.1.2. Design
The required media is designed and the results are made into a draft of the product being developed. At this stage the design includes hardware and software design. Hardware is a component needed to make a solar cell based power-bank prototype. From the results of the study, the components used can be seen in Table 1.

The solar cell based power-bank circuit looks like Figure 2. To detect the accumulator voltage value, a voltage sensor is used. The voltage measurement results are processed by Arduino and displayed on the LCD screen. This tool is connected to a relay as a connector and breaker for the electricity entering the accumulator. Software is used to activate voltage and current sensors to measure the voltage and current entering the accumulator automatically and to process data, using the C language and the Arduino integrated development environment (IDE) compiler. Arduino IDE is an editor used to write programs, compile them and upload them to the Arduino board. The media software design flow diagram is shown in Figure 3. Based on the flow diagram, the algorithm is determined as follows; i) the microcontroller actively initializes data from the voltage sensor; ii) reads the actual voltage value at the sensor voltage; iii) the sensor data is compared with predetermined conditions, if the battery voltage (battery V < 11.89 V) then the relay will close normally and the accumulator will close. If the battery voltage (V battery > 12.69 V) then the relay will open normally and the accumulator will not be charged; and iv) displays the voltage value on the LCD.

Table 1. Tools and materials

No	Tools and materials	Specification
1	Polycrystalline silicon	(Pmax): 20 W, (Vmp): 18 V, (Imp): 5.35 A, Dimensions 46x35x2 cm
2	Solar charger controller	Voltage: 12-24 V
3	Accumulator	12 V 3.5 Ah
4	Arduino Uno microcontroller	Operating voltage: 5 V, Input voltage: 7-12 V Dimensions 68.6x53.4 mm
5	Current sensor	Accurate sensing range: -5 A to +5 A operating voltage 5 V
6	Voltage sensor	Input voltage: 0-25 V DC Dimensions 25x13 mm
7	Relays	DC+: power +5 V DC DC-: power -5 V DC Dimensions 48x18x20 mm
8	USB step down charger	Input voltage: 6-24 V DC Output voltage: 1.25–35 V DC
9	LCD	Character 16x2 Voltage: 5 V Screen size 64.5x16 mm
10	USB cable tester	Input voltage: 3-7 V Input current: 50 mA–3500 mA
11	Switch	

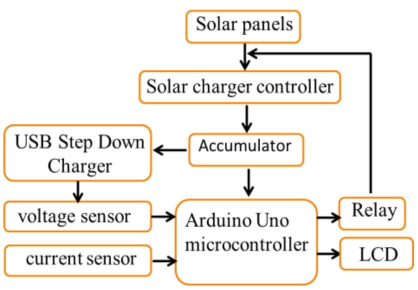

Figure 2. Flowchart of initial design of teaching aids

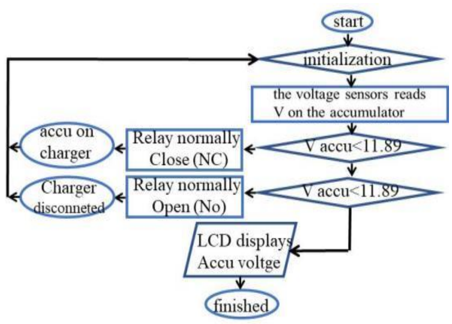

Figure 3. Flow diagram of the accumulator voltage control system

2.1.3. Development

Teaching aids that have been designed, developed and then carried out expert validation testing by 3 media expert lecturers and 1 science teacher, using the Aiken validation index with the (2).

$$V = \frac{\sum(r-Io)}{[n(c-1)]} \quad (2)$$

Information: r = number given by the assessor, Io = the lowest validity rating score, c = the highest validity rating score, and n = the number of assessors [17], [18].

2.1.4. Implementation

Product implementation uses quasi-experiments, class IX.2 is the experimental class and class IX.3 is the control class. The experimental class used a solar cell based power-bank prototype while the control class was carried out conventionally. The two classes were given a pretest and posttest in the form of questions to measure students' scientific literacy abilities in the dimensions of context, content and competency. The pretest was carried out to determine students' initial scientific literacy abilities and the posttest to see the increase in students' scientific literacy abilities after learning using teaching aids. The assessment of the dimensions of scientific attitude is carried out by filling out a questionnaire and an observation sheet in the form of a check list of 20 questions which are filled in by students and observers. The questionnaire uses a Likert scale which shows an attitude scale that includes the range of strongly agree, agree, disagree and strongly disagree. Based on Table 2 it can be seen that X1 = experimental class using a solar cell based power-bank prototype, X2 = control class using the Lecture method, Y1 = experimental class pretest results, Y2 = experimental class posttest results, Y3 = control class pretest results, Y4 = control class posttest results, and Z = validation results of the solar cell based power-bank prototype as a learning medium.

Table 2. Implementation design

No	Treatment	Test		Questionnaire
1	X1	Y1	Y2	Z
2	X2	Y3	Y4	

2.2. Data collection technique

To measure scientific literacy in terms of context, content and competence, a test in the form of essay questions with 7 questions was used. The test is a series of questions used to measure skills, intelligence knowledge, abilities or talents possessed by individuals or groups [19], carried out as a pre-test and post-test in both the experimental class and the control class. While the technique of collecting data on the attitude dimension uses a questionnaire. Questionnaire is a data collection technique that is carried out by giving a set of questions or written statements to respondents to answer [20]. Meanwhile, the observation sheet is filled in by the observer during the learning activities to find out students' scientific attitudes.

2.3. Data analysis techniques

2.3.1. Data analysis validation test by experts

Validation tests for teaching aids, LKPD, and literacy questions were carried out by 4 validate. The validation test of the questionnaire and attitude observation sheet was carried out by 5 experts. The validation test results were analyzed using the Aiken V coefficient equation [21] using (3).

$$V = \frac{\sum(r-Io)}{[n(c-1)]} \quad (3)$$

Note: r = number by rater, Io = lowest validity number, highest validity number, and n = number of raters. Based on the minimum standard, Aiken's V is set at 0.92 with a standard error of 5%. Meanwhile, the results of the questionnaire validation test and student science attitude observation sheets were analyzed using the content validity ratio (CVR) [22], [23] using (4).

$$CVR = \frac{2\,ne}{n} - 1 \quad (4)$$

Information: ne = the number of SMEs who assess an essential item and n = the number of SMEs who carry out the assessment. If half of the SMEs say they are essential then the CVR will have a value of 0, and CVR will have a value of 1 if all the SMEs say they are essential for an item. Items that obtain a negative CVR value must be eliminated, based on the minimum CVR value for 5 validators, namely 0.99.

2.3.2. Analysis of scientific literacy items

a) Validity test

Valid means that the instrument can measure what it wants to measure. Validity is a measure that shows the levels of validity of an instrument [24]. To measure the validity of an instrument, the product moment correlation formula is used, which is as (5).

$$rxy = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[(N\sum x^2) - (\sum x)^2] - [(N\sum y^2) - (\sum y)^2]}} \tag{5}$$

Description: rxy = correlation coefficient between variables x and y, N = number of samples taken, Σx = total score of independent variable x, Σy = total score of dependent variable y, x = score of variable x, y = score of variable y, Σx^2 = total the square of the score of the variable x, and Σy^2 = The sum of the squares of the score of the variable y. The criteria for determining significant by comparing the value of r-count and r-table. If r-count > r-table, then we can conclude that the item is valid.

b) Reliability test

Reliability is the reliability of an instrument to be used as a data collection tool because the instrument is good [25]. Reliability is calculated using the Cronbach's alpha formula as (6).

$$r11 = \frac{k}{k-1} x \{1 - \frac{\sum S_i^2}{S_t^2}\} \tag{6}$$

Description: $r11$ = Cronbach's alpha reliability coefficient, k = number of question items, $\sum S\text{i}^2$ = total variance of scores of each item, and St^2 = total variance. The criteria for a research instrument are said to be reliable with this technique if the reliability coefficient is r11 > 0.6 [26].

2.3.3. Field test results data analysis techniques

a) Data analysis of the results of increasing scientific literacy ability

An analytical test to improve scientific literacy skills is carried out using the results of the pretest and posttest with normalized N-Gain calculations expressed by (7).

$$N_{Gain} = \frac{x_2 - x_1}{x_3 - x_1} \tag{7}$$

Where x_1 = pretest score, x_2 = posttest score, and x_3 = maximum score. N-gain scores are grouped into high, medium, and low categories which can be seen in Table 3.

Table 3. N-gain score interpretation criteria

N_{Gain} Percentage	Interpretation
> 0.7	Tall
≥ 0.3 - ≤ 0.7	Currently
< 0.3	Low

b) Questionnaire analysis and scientific attitude observation sheet

Scientific attitude data analysis was carried out to determine the achievement of students' scientific attitudes. This attitude questionnaire uses a Likert scale with a maximum score for each item of 4 and a minimum score of 1. Here's how to score students' scientific attitudes using a Likert scale of 4 [27]. Percentage of scientific attitude by way of a raw score into percentages based on (8).

$$Percentage = \frac{Obtained\ Total\ Score}{Maximum\ Total\ Score} \times 100\% \tag{8}$$

Table 4 explains that. To obtain accurate data about students' scientific attitudes, negatively and positively oriented questions and statements are needed in a questionnaire with the options of strongly agree, agree, disagree, and strongly disagree with a score range of 1-4. Interpretation of attitude percentages refers to the criteria in Table 5 [28].

Table 4. Scoring of students' scientific attitudes

Respondents answer	Positively oriented	Negatively oriented
Strongly agree	4	1
Agree	3	2
Don't agree	2	3
Strongly disagree	1	4

Table 5. Attitude percentage interpretation criteria

Percentage (%) student response	Criteria
0.00% - 20.00%	Very less
20.01% - 40.00%	Not enough
40.01% - 60.00%	Enough
60.01% - 80.00%	Good
80.01% - 100%	Very good

3. RESULTS AND DISCUSSION

3.1. Analysis

The results of the student questionnaire analysis regarding the obstacles experienced when learning science are shown in Figure 4, while the results of a student questionnaire about the learning media used in science learning are shown in Figure 5. The results of the student questionnaire analysis related to the need for the development of solar cell-based renewable energy teaching aids at SMPN 4 Bengkulu Tengah can be seen in Figure 6.

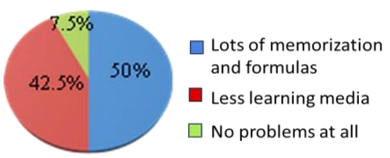

Figure 4. Percentage diagram of obstacles faced by students while studying science

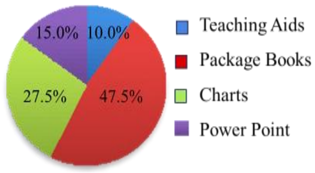

Figure 5. Percentage diagram of learning media used

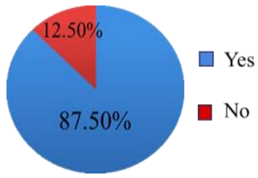

Figure 6. Percentage diagram of the need for teaching aids developed

An understanding of renewable and non-renewable energy sources and their application in everyday life is needed to provide broad insight to students. This is in line with the opinion of [29] which states that renewable energy must be introduced from the start through classroom learning with the aim of increasing awareness of the importance of energy in life. The use of energy teaching aids that students practice directly further optimizes the delivery of the material [30]. Learning with teaching aids makes it easier for students to hone their skills because students understand how to use, utilize and apply them in life [31].

Based on the data above, 35 respondents (87.5%) need teaching aids, according to the results of interviews with teachers. This is in line with research which concludes that the electrical energy conversion tool as a learning media developed is very suitable for use in the learning process [32]. For this reason, the introduction of solar panel technology is needed so that the younger generation becomes technologically literate earlier [33]. The teaching aid developed is a "solar cell based power-bank" prototype as in Figure 7. The components used are a solar charger controller, battery, Arduino microcontroller, current sensor, voltage sensor, relay, LCD, step down module and USB cable. The solar panel converts sunlight energy into electrical energy, before entering the battery, the solar panel voltage passes through the solar charger controller to regulate the charging of the electrical energy entering the battery. After the voltage enters the battery, this voltage can be directly utilized by the DC load via the battery using a step down converter module. The voltage and current in the battery are detected by voltage and current sensors. The voltage and current values are managed by the Arduino Uno microcontroller and then displayed on the LCD. The teaching aids are then assembled according to the initial design that has been determined. The appearance of the solar cell based power-bank used as a renewable energy demonstration tool can be seen in Figure 8. The solar cell power-bank shows students the phenomenon of changing solar energy into electrical energy, storing the electrical energy produced and directly utilizing the energy produced by connecting it to a cellphone, equipped with a worksheet that can be used as a guide for students to carry out experiments. This tool was validated by 4 validate, 3 media expert lecturers and 1 science person, with 5 indicators which include: i) technical components with 9 assessment items, ii) efficiency of the tool which contains 3 assessment items, iii) accuracy of the tool which contains 1 assessment item, iv) security of the tool which contains 1 assessment item, and v) usefulness of the tool which contains 2 assessment items. The validation test results can be seen in Table 6. Based on Table 6 and the standards set by Aiken, obtained from the assessment of the four validators for teaching aids of 0.982 > minimum standard V Aiken (0.92), so that solar cell based power-bank teaching aids are valid and appropriate to be used as a support for science learning in the context of renewable energy at the junior high school level.

Figure 7. Initial design of props

Figure 8. Solar cell based power-bank display tool

Table 6. Expert validation test results for teaching aids

No	Assessment indicator	$\Sigma(r-I_0)$	n (c-1)	V	Information
1	Tool technical components	11.88	12	0.99	Valid
2	Tool efficiency	12	12	1	Valid
3	Tool accuracy	11	12	0.92	Valid
4	Tool security	12	12	1	Valid
5	Tool benefits	12	12	1	Valid
	Average			0.982	Valid

3.2. Research device validation test

Before implementing the learning, all research instruments have been validated, including validation tests; teaching aids, LKPD, questionnaire/observation sheet on students' scientific attitudes, question items, reliability of question items, Level of difficulty, discrimination test, normality and homogeneity of questions. From Table 7 it can be seen that the attributes, student worksheets, and questionnaires are declared valid with scores of 0.98, 0.98, and 0.99. 7 questions were declared valid because > from t table 0.444 and 3 were invalid < from t table 0.444. 8 questions were declared reliable because > from t table 0.632 and 2 were unreliable < from t table 0.632. The level of difficulty of the questions and the differentiating power of the questions were stated as good for 1 question, fair for 7 questions, and bad for 2 questions. The sample was declared homogeneous and normal. The research work hypothesis is accepted, this means that the teaching aids used in science learning influence the increase in students' scientific literacy. Questions that are not yet valid, not yet verifiable, have different levels of difficulty, and are poorly revised.

Table 7. Research device validation test

No	Assessment indicator	Score	item	Information
1	Props	0.98	15	Valid
2	Student worksheet	0.98	13	Valid
3	Questionnaire/observation sheet	0.99	20	Valid
4	Validity of question items		1, 2, 4, 5, 6, 8, 10	Valid
			3, 7, 9	Invalid
5	Test item reliability	0.670	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Reliable
6	Difficulty level		7 and 9	Bad
			1, 2, 3, 4, 5, 8, 10	Enough
			6	Good
7	Discriminating power of questions		7 and 9	Bad
			1, 2, 3, 4, 5, 8, 10	Enough
			6	Good
8	Homogeneity	0.570		homogeneous
9	Normality	0.05		normal
	Hypothesis testing	0.000		Ha accepted

3.3. Results of implementation of solar cell based power-bank prototype teaching aids in science learning implementation of learning in experimental and control classes

Learning was carried out in 3 meetings in both experimental and control classes. At the first meeting, it is carried out to determine the student's initial abilities. Then continued with the distribution of environmentally friendly technology material LKPD. In the experimental class, students are asked to discuss problems on the LKPD related to renewable energy sources and then present the results of the discussion in front of the class. Meanwhile, in the control class, learning was carried out using the lecture method. At the second meeting of the experimental class, the researcher demonstrated and tested the solar cell power-bank prototype teaching aid to the students and explained the function of each component and how it worked. In the control class, the material is explained through lectures and discussions. The third meeting of environmentally friendly technology applications, in the experimental class, learning continued by conducting experiments using a prototype solar cell power-bank. Meanwhile, in the control class, material is discussed through discussion and observation through video shows using PowerPoint media. At the end of the lesson, both the experimental and control classes carried out a final test, namely a post test and filling out a questionnaire on students' scientific attitudes. Meanwhile, the observation sheet for students' scientific attitudes is filled in by the observer during the lesson.

3.4. Results of analysis of increasing students' science literacy between experimental and control classes as a whole

Data on differences in increasing scientific literacy between experimental and control classes based on objective test results in learning environmentally friendly technology material. The average results of the pretest, posttest and N-gain of scientific literacy for students in the experimental class and control class can be seen in Figures 9 and 10. Based on Figures 9 and 10, there are differences in the average pretest and posttest scores obtained by the experimental and control classes. The average pretest and posttest scores in the experimental class were 35.71 and 81.21, an increase of 45.5, the N-gain value was 0.71 (high category). Meanwhile, in the control class the average pretest and posttest scores were 33.07 and 70.03, an increase of 36.96, the N-gain value was 0.55 (medium category). It can be concluded that the increase in post-test scores and N-gain values for the experimental class were higher than the posttest scores for the control class.

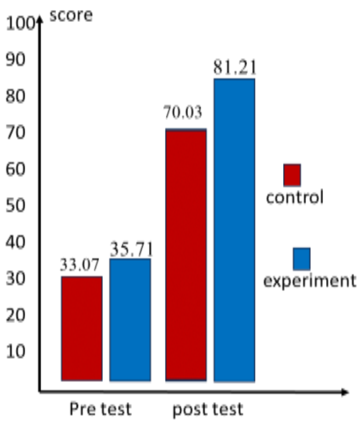

Figure 9. Average pretest and posttest class experiment and control

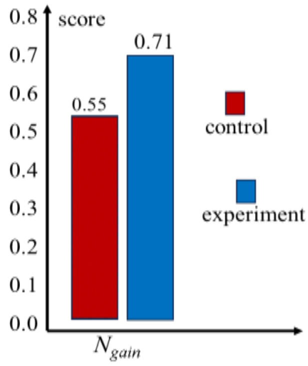

Figure 10. Comparison of N-gain values for experimental and control classes

3.5. Results of analysis of increasing scientific literacy of students in experiment class and control class based on problem indicators

This finding is in line with other opinions, namely; an important aspect in assessing scientific literacy is student involvement in various situations presented in the form of scientific issues. The context dimension of scientific literacy concerns important issues related to science in everyday life. Scientific literacy assessment items are designed for contexts that are not only limited to school life, but also the context of students' lives in general [34]-[36]. PISA focuses on personal, social and global situations and topics to understand scientific progress. The PISA scientific literacy assessment assesses content, competencies and context-related attitudes. The context dimension indicators in this research refer to the involvement of science and technology in the natural resources sector which includes renewable and non-renewable energy as well as the application of technology in the energy sector [37]-[40]. Indicators in the content dimension include content knowledge, procedural knowledge, and epistemic knowledge. Meanwhile, indicators in the competency dimension include explaining scientific phenomena, evaluating and designing scientific investigations, interpreting scientific data and evidence.

3.6. Based on the dimensions of science literacy

The difference in increasing scientific literacy between the experimental and control classes in each dimension can be seen through the results of the pretest, posttest and N-gain scores in each dimension of students' scientific literacy in the two classes. Overall, the increase in scientific literacy by comparing the N-gain values per dimension of scientific literacy between the experimental and control classes can be seen in Figures 11-13. Based on Figure 11, the average N-gain for each dimension of scientific literacy in the experimental class is higher than in the control class. In the experimental class, the highest N-gain value was found in the context dimension of 0.73 (high category) while the content and competency dimensions had the same average N-gain, namely 0.69 (medium category). Meanwhile, for the control class, the highest average N-gain was also found in the context dimension at 0.57 (medium category) and the lowest in the competency and content dimensions at 0.53 (medium category). Thus, it was concluded that the overall increase in scientific literacy in the experimental class based on the dimensions of scientific literacy was higher than in the control class. Based on the results of the analysis of the pretest and posttest answers of experimental and control class students from 7 scientific literacy questions which included the context, content and competency dimensions tested on environmentally friendly technology material, there was an increase in N-gain in the context dimension which can be seen in Figure 12.

Based on Figure 12, information is obtained that increasing scientific literacy in the context of renewable energy in the experimental class has an N-gain value of 0.84 (high category), greater than the N-gain of the control class of 0.67 (medium category). Meanwhile, in the context of applying energy technology, the control and experimental classes are in the same N-gain category, namely medium, but the N-gain value obtained by the experimental class is greater (0.63) than the control class, namely (0.46). Based on Figure 13, information on increasing scientific literacy in the content dimension in the content knowledge aspect of the experimental class has an N-gain value of 0.8 (high category) and in the control class 0.68 (medium category). Meanwhile, in the procedural knowledge aspect, the experimental class students excelled with an N-gain value of 0.71 (high category) and the control class N-gain value of 0.50 (medium category). Meanwhile, the experimental and control epistemic knowledge aspects are in the same category, namely medium, but the N-gain value for the experimental class is 0.54 greater than the control class, namely 0.43. The content knowledge aspect is the aspect that has the highest average N-gain value among other aspects.

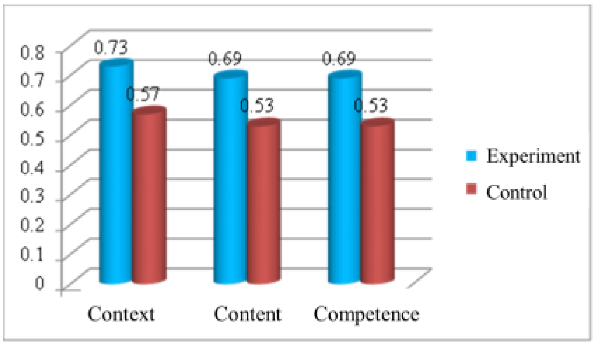

Figure 11. Graph of comparison of N-gain values for each dimension of scientific literacy

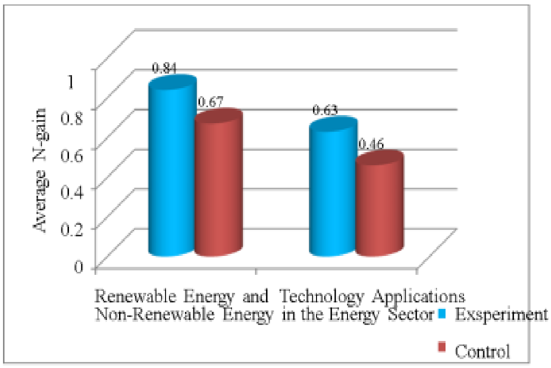

Figure 12. Graph comparison of context dimension N-gain values

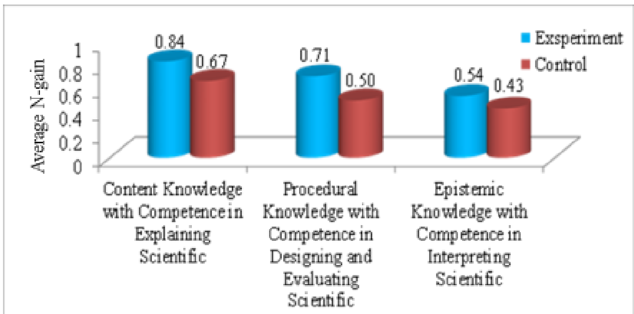

Figure 13. Graph of comparison of N-gain values on content and competency dimensions

The increase in the N-gain value shows that the control and experimental class students are good at understanding the concept of energy and its changes that have been studied. Learning in schools has generally placed more emphasis on scientific concepts and theories so that students are accustomed to repeating the material they have studied. This is in line with the results of research [41] which states that the percentage of students' content knowledge is higher because the learning process in class places more emphasis on cognitive aspects. The high ability of students to understand the material is due to the students' own abilities and students are helped by the solar cell power-bank prototype teaching aids used during learning. This finding is in line with the results of research [42], [43] which states that teaching aids help students understand the material, increase enthusiasm for learning and reduce boredom. Through visual aids, students can prove directly how sunlight is converted by solar panels to produce electricity. The smallest N-gain value is found in the aspect of epistemic knowledge, namely ideas obtained from evidence and facts related to science. Epistemic knowledge refers to knowledge about science by using evidence or facts to draw conclusions [44]. The reason for the low ability of students to interpret scientific data is because science learning is carried out using the lecture method and rarely carries out practical activities so that students are not used to conducting investigations, interpreting data and drawing conclusions based on experimental data so they are less able to think to make conclusions [45], [46].

Apart from the context, content and competency dimensions, the science attitude dimension is an important aspect that influences students' scientific literacy abilities. The dimensions of scientific attitude are measured using observation sheet instruments by observers and questionnaires by students. The assessment results for each indicator are calculated based on percentages so that differences in students' answers are clearly visible and easier to analyze. Scientific attitude includes 4 indicators, namely an attitude of curiosity, respect for data, willingness to change views and an attitude of critical reflection. The results of observing students' scientific attitudes were obtained from observation sheets and questionnaires filled out by students at the end of the lesson. Apart from calculating the scientific attitude score for each class, students' answers are classified into each observed indicator. Based on the recapitulation of the calculation results of the observation sheets in the experimental and control classes at each meeting, the data obtained is presented in Figure 14.

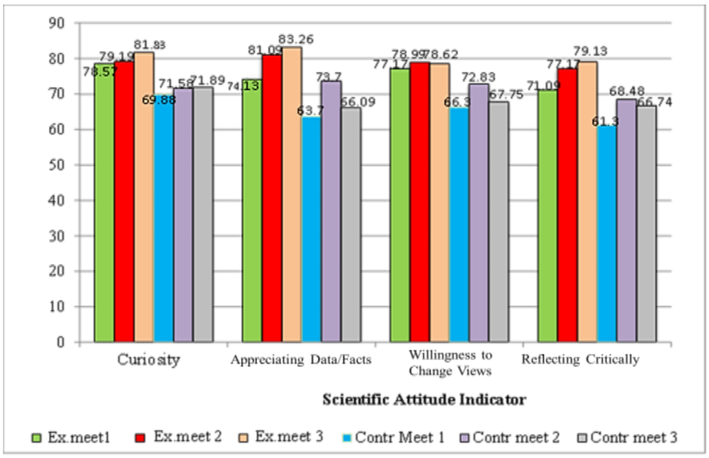

Figure 14. Percentage analysis of the scientific attitude observation sheet

Based on Figure 14, the percentage of curiosity, appreciation of data, and willingness to change views and carry out critical reflection has increased and decreased. At meeting 1, the percentage difference in the curiosity aspect of the experimental and control classes (78.57% and 69.88%) was 8.69%. The percentage difference between data appreciation indicators for the experimental class and the control class (74.13% and 63.7%) is 10.43%. The percentage difference in willingness to change the views of the experimental class and the control class (77.17% and 66.3%) was 10.87%. Meanwhile, the percentage difference in indicators reflecting criticality in the experimental and control classes (71.09% and 61.3%) was 9.79%. At the second meeting, it was seen that the percentage obtained by the experimental class was superior to the control class. The percentage difference in the curiosity indicator in the experimental and control classes (79.19% and 71.58%) was 7.61%, in the data indicator (81.09% and 73.7%) it was 7.39%, in the curiosity indicator (81.09%) and 73.7 %) was 7.39%, willingness to change views (78.99% and 72.83%) was 6.16% and critical thinking indicators (77.17% and 68.48%) were 8.69%. Based on Figure 14, the percentage of scientific attitudes at the third meeting, the experimental group is the group with the superior percentage. Of all the indicators at the third meeting, the lowest percentage was the respect for data indicator of 66.09%. Based on Figure 15, it is known that the percentage difference in the curiosity aspect of the experimental and control classes (78.88% and 76.09%) is 2.79%. The percentage difference in indicators of respect for data in the experimental and control classes (76.96% and 68.91%) was 8.05%. The percentage difference in indicators of willingness to change the views of the experimental and control classes (80.8% and 73.91%) was 6.89%. Meanwhile, the percentage difference in indicators that reflect criticality in the experimental and control classes (75% and 65.65%) is 9.35%. Overall, the comparison of the average percentage of observation sheets and scientific attitude questionnaires between experimental and control class students can be seen in Figures 15 and 16.

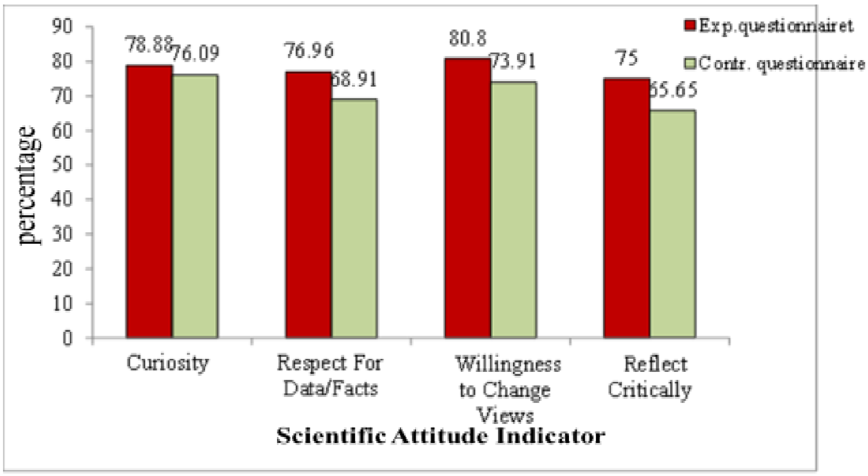

Figure 15. Percentage diagram of students' scientific attitude indicators based on questionnaires in experimental and control classes

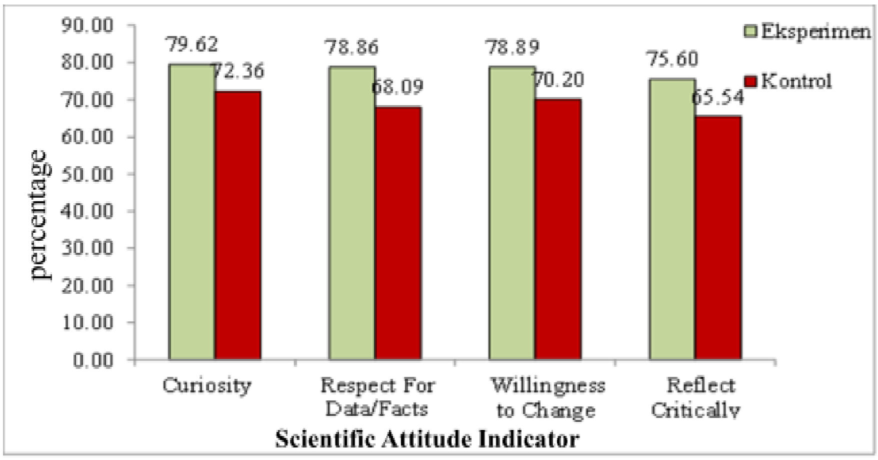

Figure 16. Comparison of percentage of scientific attitude indicators of students based on average observations and questionnaires in experimental and control classes

Based on Figure 16, the percentage difference in curiosity indicators between the experimental class and the control class is 7.26%. The indicator of respect for data/facts has a difference of 10.77%. Meanwhile, the indicators of willingness to change views and reflect critically have differences of 8.69% and 10.06% respectively. Figure 16 shows that the curiosity indicator has the highest percentage in both the experimental and control classes, namely 79.62% and 72.36%. The curiosity indicators in the experimental and control classes were in the good category. This shows that the majority of students in both classes have a high curiosity in studying science material on environmentally friendly technology. The curiosity indicators observed in this study consisted of showing interest in new things and carrying out investigations in response to these new things. Interest in new things is observed through factual activities such as wanting to know what other people are talking about, noting important points from the teacher's explanation and asking questions that are not yet understood. In the learning process, students are asked to investigate problems in the LKPD, namely problems related to phenomena related to renewable energy sources and environmentally friendly technology products. The problems given aim to foster curiosity and require students to investigate the problem by looking for as much information as possible about renewable energy sources and energy changes in solar panels from various sources such as listening to teacher explanations, reading books, the internet. or discuss with other people in the group to answer this curiosity. Presenting problems in learning can stimulate students' curiosity so that students are motivated to continue learning and want to continue looking for answers to their questions or curiosity [47].

The percentage on the aspect of respect for data or facts for the experimental class (78.86%) is greater than the percentage for the control class (68.09%). Indicators of respect for the data/facts of the experimental and control classes are in the good category. This shows that most students are quite good at reporting experimental data or discussions and comparing data based on evidence. In the experimental class, respect for facts was shown by students carrying out investigations through practicum directly using solar cell-based power-bank prototype props so that students got evidence or data relevant to the practicum results. The data that students get is used to complete the LKPD in accordance with the actual measurement results, direct measurement makes the resulting data more accurate because students see directly the object that students are observing and report the data obtained as it. is without manipulating it and can compare it with other groups so that respect for data/facts is more visible. This opinion is in line with research on Integrated Science learning, which is a complex learning activity and must be carried out honestly. This research focuses on understanding scientific concepts in the fields of physics, biology and chemistry as a whole. For this reason, it is necessary to develop science teaching aids based on project based learning as a unit for understanding concepts and experiments. The aim is for students as prospective teachers to have better competence, students are trained to be honest in processing data and thorough in order to obtain information that is as valid as possible. Development is carried out based on project-based learning using the Plomp development model at the prototyping stage, especially at the prototyping stage at the expert review stage. The research results show that science teaching aids are valid for use in learning to analyze practicality and effectiveness [48].

In the aspect of willingness to change views, the average percentage of attitudes in the experimental class was 78.89% in the good category and the control class was 70.209% which was also in the good category. The willingness to change views observed in this study includes a willingness to change ideas when they conflict with facts, to be able to seek alternative ideas, and to realize new views that are in accordance with scientific facts. Learning in both experimental and control Classes was carried out by group discussion activities. Discussion activities will foster an attitude of mutual cooperation because discussing can solve problems and find concepts. This shows that experimental and control class students are good at accepting differences of opinion regarding solving a problem, are ready to change ideas that are raised when they conflict with convincing facts, and are able to tolerate and respect different opinions and answers from their group mates. In the aspect of critical reflecting, the average percentages of the experimental and control classes were 75.60% and 65.54%, respectively. The attitude indicator reflects critically on the experimental and control class students in the good category. This shows that the majority of students in both classes have been able to properly review what they have investigated, consider alternative procedures used, and discuss and improve the procedures to be used.

Figure 16 Shows that the attitude of critical reflection, even though it is in a good category, has a lower percentage than other science attitude indicators. This attitude requires students to play an active role in finding the correct answer and conducting experiments to present the results of the experiment and find the right answer, at this stage students must be able to review the activities that have been carried out. Learning activities in the experimental and control classes, students are faced with problems that must be discussed to find answers. In addition, students were asked to present the results of the discussion. During presentations, students are required to listen and consider the results of reports from each group and be able to reflect on their answers on the answers of other groups. While in a small number of students in the experimental and control class, the attitude indicator had not yet appeared. Based on the description above, it can be concluded that the results of the assessment of the science attitude of the experimental and control class students as a whole are already in the good category because the percentage gain is in the range of 60.01% - 80.00%.

Based on Table 8, it is known that the sig. (2 tailed) obtained 0.000. This value is less than 0.05 which means Ha is accepted and Ho is rejected. This means that the teaching aids used in science learning affect the increase in students' scientific literacy. Research conducted [49], [50] also states that the use of visual aids in learning science for locomotion materials can increase students' scientific literacy. The results of this study also show that the use of solar cell-based power-bank prototype teaching aids in natural science learning on environmentally friendly technology materials influences the increase in scientific literacy of SMPN 4 Bengkulu Tengah students. The above findings are in line with other research results which state that collaborative learning groups and the operation of a web-based instant response system for material on scientific concepts about solar cells and energy sources among high school students show statistically significant advantages in scientific concepts about solar cells, energy sources and science literacy scores [51], [52]. Learning energy literacy concepts allows citizens to contribute effectively to energy efficiency and sustainability, but energy literacy does not correlate strongly with energy consumption habits. Energy literacy covers the cognitive, affective and behavioral domains that enable society to make the right decisions regarding sustainable energy, therefore it is necessary to carry out promotional research at various levels of education [53]-[58].

Table 8. Hypothesis test results

		Independent samples test								
		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	T	Df	Sig.(2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
N-gain score	Equal variances assumed	0.000	0.989	5.700	44	0.000	0.16117	0.02828	0.10418	0.21816
	Equal variances not assumed			5.700	43.697	0.000	0.16117	0.02828	0.10417	0.21817

4. CONCLUSION

The feasibility level of the solar cell-based power-bank prototype demonstration tool based on expert validation results obtained an average V Aiken index of 0.98 (feasible category). Meanwhile, the LKPD obtained an average value of the V Aiken index of 0.97 (decent category) and was used as a science learning prop for environmentally friendly technology material. Meanwhile, based on the results of testing the components and system of the tool as a whole, it shows that all components of the solar cell-based power-bank prototype function well. The use of solar cell-based power-bank prototype teaching aids can increase students' scientific literacy. Overall, there is a difference in the N-gain value between the experimental and control classes. The experimental class obtained an N-gain value of 0.71 (high category) while the control class was 0.55 (medium category). In the context dimension, the increase in N-gain in the experimental class was 0.73, greater than the control class, which was 0.57. In the content and competency dimensions, the N-gain value for the experimental class was 0.69 and the control class was 0.53. Meanwhile, in the attitude dimension, the average percentage of attitude obtained in the experimental class was higher than in the control class, the indicator of curious attitude obtained the highest percentage in both classes, namely 79.62% in the experimental class and 72.36% in the control class, the indicator of respect for data obtained 78.86% in the experimental class and the control class was 68.09%. The indicator of willingness to change views obtained 78.89% in the experimental class and 70.20% in the control class. Meanwhile, the attitude indicator to reflect critically obtained the lowest percentage, namely 75.60% in the experimental class and 65.54% in the control class. Meanwhile, based on the results of the hypothesis test, the sig (2 tailed) value was 0.000, which is smaller than 0.05, which means Ha is accepted and Ho is rejected. This means that the solar cell-based power-bank prototype teaching aid used in science learning influences the increase in students' scientific literacy.

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REFERENCES

[1] S. Hartini, D. S. Abyati, and A. S. M., "Developing high school physics teaching materials through 7E learning cycle model," *Journal of Physics: Conference Series*, vol. 1422, no. 1, p. 012032, 2020, doi: 10.1088/1742-6596/1422/1/012032.

[2] H. S. T. Utari, R. Budiharti, Sukarmin, D. Wahyuningsih, and F. F. Haryani, “Development of Learning Media Moodle-Based on Static Fluids,” *Jurnal Penelitian Pendidikan IPA*, vol. 9, no. 10, pp. 8713–8721, 2023, doi: 10.29303/jppipa.v9i10.4367.

[3] S. Widuri, M. M. Chusni, and E. K. Yuningsih, “Koflusa learning media for static fluid,” *Journal of Physics: Conference Series*, 2019, vol. 1175, no. 1, doi: 10.1088/1742-6596/1175/1/012181.

[4] N. A. Lestari, R. A. N. Rahman, R. A. Pratami, E. P. D. N. Sari, and Dwikoranto, “Implementation of Physics Concepts in Energy Conversion-Based Electronic Devices as Physics Teaching Materials,” *Studies in Philosophy of Science and Education*, vol. 2, no. 3, pp. 84–94, 2021, doi: 10.46627/sipose.

[5] Eliyawati, Y. Sunarya, and A. Mudzakir, “Solar Cell as Learning Multimedia to Improve Students’ Scientific Literacy on Science and Nanotechnology,” *Journal of Science Learning*, vol. 1, no. 1, pp. 36–43, 2017.

[6] H. J. Banda and J. Nzabahimana, “The Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Motivation and Academic Achievement Among Malawian Physics Students,” *Journal of Science Education and Technology*, vol. 32, no. 1, pp. 127–141, 2023, doi: 10.1007/s10956-022-10010-3.

[7] A. Rusilowati, L. Kurniawati, S. E. Nugroho, and A. Widiyatmoko, “Developing an Instrument of Scientific Literacy Asessment on the Cycle Theme,” *International Journal of Environmental & Science Education*, vol. 11, no. 12, pp. 5718–5727, 2016.

[8] J. Afriana, A. Permanasari, and A. Fitriani, “Project based learning integrated to stem to enhance elementary school’s students scientific literacy,” *Jurnal Pendidikan IPA Indonesia*, vol. 5, no. 2, pp. 261–267, 2016, doi: 10.15294/jpii.v5i2.5493.

[9] B. A. G. Bossin, “Demonstrating sustainable energy: A review based model of sustainable energy demonstration projects,” *Renewable and Sustainable Energy Reviews*, vol. 77, pp. 1349–1362, 2017, doi: 10.1016/j.rser.2017.02.002.

[10] K. Hori, T. Matsui, T. Hasuike, K. Fukui, and T. Machimura, “Development and application of the renewable energy regional optimization utility tool for environmental sustainability: REROUTES,” *Renewable Energy*, vol. 93, pp. 548–561, 2016, doi: 10.1016/j.renene.2016.02.051.

[11] Y. M. Cholily, A. In’am, S. Inganah, and M. M. Effendi, “The Learning of the Solar Cell Electricity among the Students in Junior High School,” *Energy Economics Letters*, vol. 6, no. 1, pp. 17–22, 2019.

[12] F. A. Samman, N. Umniyah, F. Febriyana, and Syafaruddin, “Arduino Uno AVR Atmega328 microcontroller based dual axis solar tracker design,” *ICIC Express Letters Part B: Applications*, vol. 13, no. 4, pp. 337–345, 2022, doi: 10.24507/icicelb.13.04.337.

[13] W. L. Filho *et al*., “Realising the Potential of Renewable Energy as a Tool for Energy Security in Small Island Developing States,” *Sustainability*, vol. 14, no. 9, p. 4965, 2022, doi: 10.3390/su14094965.

[14] M. I. Fahmi, Hidayatullah, J. E. Hutagalung, and S. Sembiring, “Electrical Automation of Solar Cell-Based Arduino Uno with 16x2 LCD Display,” *Proceedings of MICoMS 2017*, 2018, vol. 1, pp. 629–639, doi: 10.1108/978-1-78756-793-1-00099.

[15] M. Matsun, B. Boisandi, I. N. Sari, S. Hadiati, and D. Hidayat, “Development of mechanical energy teaching aids based on Arduino Uno microcontroller assisted ultrasonic sensors and load cells,” *Jambura Physics Journal*, vol. 3, no. 2, pp. 135–148, 2021, doi: 10.34312/jpj.v3i2.11703.

[16] Y.-C. Chou, H.-Y. Yen, H.-W. Yen, Y.-L. Chao, and Y.-H. Huang, “The effectiveness of teaching aids for elementary students’ renewable energy learning and an analysis of their energy attitude formation,” *International Journal of Environmental and Science Education*, vol. 10, no. 1, pp. 39–49, 2015.

[17] I. Ahmed and S. Ishtiaq, “Reliability and validity: Importance in Medical Research,” *Methods*, vol. 71, no. 10, pp. 1401–2406, 2021.

[18] E. Chetwynd, “Critical Analysis of Reliability and Validity in Literature Reviews,” *Journal of Human Lactation*, vol. 38, no. 3, pp. 392-396, 2022, doi: 10.1177/08903344221100201.

[19] D. A. Saputri, H. Hasratuddin, and B. Sinaga, “Development of Discovery Learning Model-Based Learning Media to Improve Student Mathematical Reasoning,” *American Journal of Educational Research*, vol. 8, no. 2, pp. 98–104, 2020, doi: 10.12691/education-8-2-5.

[20] K. B. Praveena and K. S. Srinivasa, *Research Methodology A Practical Approach*. New York, NY, USA: ESQUIRE Publications, 2011.

[21] N. Hidayah and Muhtarom, “Validity and Reliability Test of Teaching Materials Using Aiken's V Formula and SPSS 22,” *SCHOLA*, vol. 1, no. 2, pp. 75–82, 2023.

[22] L. R. Gay, G. E. Mills, and P. W. Airasian, *Educational research: competencies for analysis and applications*. London, UK: Pearson, 2012.

[23] C. V. Mesa, F. J. S. Pastor, and M. J. M. Segura, “The challenge of competencies in training for educational research: a conceptual approach,” *Actualidades Investigativas en Educación*, vol. 19, no. 3, pp. 310–339, 2019, doi: 10.15517/aie.v19i3.38738.

[24] B. M. Werner and W. E. Souder, “Measuring R&D Performance—State of the Art,” *Research-Technology Management*, vol. 40, no. 2, pp. 34–42, 2016, doi: 10.1080/08956308.1997.11671115.

[25] H. J. Thamhain, “Assessing the Effectiveness of Quantitative and Qualitative Methods for R&D Project Proposal Evaluations,” *Engineering Management Journal*, vol. 26, no. 3, pp. 3–12, 2015, doi: 10.1080/10429247.2014.11432015.

[26] J. A. Gliner, G. A. Morgan, and N. L. Leech, *Research Methods in Applied Settings: An Integrated Approach to Design and Analysis*. New York, NY, USA: Routledge, 2009.

[27] W. Park and S.-G. Kim, “Integrating quantitative and qualitative methodologies to build a national R&D plan using data envelopment analysis based on R&D stakeholders’ perspectives,” *PLoS ONE*, vol. 17, no. 3, p. e0265058, 2022, doi: 10.1371/journal.pone.0265058.

[28] D. Ary, L. C. Jacobs, and C. Sorensen, *Introduction to Research in Education*. Belmont, CA, USA: Wadsworth, 2010.

[29] S. Shehzad, J. Afzal, and G. Anwar, “Significance of ‘Renewable Energy Education' in Curriculum of Students,” *Academy of Education and Social Sciences Review*, vol. 3, no. 3, pp. 361–373, 2023, doi: 10.48112/aessr.v3i3.603.

[30] M. S. Uddin and A. Sultana, “Promoting Renewable Energy Education to Middle School and High School Students Through Sponsored Summer Camps,” *Evolutions Mechanical Engineering*, vol. 5, no. 3, pp. 1–12, 2024, doi: 10.31031/EME.2024.05.000611.

[31] A. T. D. Perera and P. Kamalaruban, “Applications of reinforcement learning in energy systems,” *Renewable and Sustainable Energy Reviews*, vol. 137, p. 110618, 2021, doi: 10.1016/j.rser.2020.110618.

[32] A. Rohman, I. K. Werdhiana, and S. Saehana, “The development of electrical energy conversion tools as learning media for the concept of energy sources,” *Journal of Physics: Conference Series*, 2021, vol. 1760, no. 1, doi: 10.1088/1742-6596/1760/1/012051.

[33] N. R. Wahidin, E. C. Prima, and Riandi, “Development of solar cell experiment for junior high school: investigating the effect of wavelength on current and voltage,” *Research in Physics Education*, vol. 2, no. 2, pp. 105–115, 2024, doi: 10.31980/ripe.v2i2.35.

[34] B. Hayat, “Literacy of our youngsters: results and restraints from PISA,” *International Journal of Education*, vol. 5, no. 1, pp. 1–16, 2010.

[35] D. Ardianto and B. Rubini, "Comparison of students' scientific literacy in integrated science learning through model of guided discovery and problem based learning," *Jurnal Pendidikan IPA Indonesia*, vol. 5, no. 1, pp. 31-37, 2016, doi: 10.15294/jpii.v5i1.5786.
[36] A. Adriyawati, E. Utomo, Y. Rahmawati, and A. Mardiah, "Steam-project- based learning integration to improve elementary school students' scientific literacy on alternative energy learning," *Universal Journal of Educational Research*, 2020, vol. 8, no. 5, pp. 1863–1873, 2020.
[37] OECD, *PISA 2009 Assessment Framework. Key competencies in reading, mathematics and science*. Paris, France: OECD Publishing, 2010, doi: 10.1787/9789264062658-en.
[38] OECD, "PISA 2015 Results in Focus," *PISA in Focus*, no. 67, 2016, doi: 10.1787/aa9237e6-en.
[39] M. Istyadji and Sauqina, "Conception of scientific literacy in the development of scientific literacy assessment tools: A systematic theoretical review," *Journal of Turkish Science Education*, vol. 20, no. 2, pp. 281–308, 2023, doi: 10.36681/tused.2023.016.
[40] I. A. Amala, S. Sutarto, P. D. A. Putra, and I. Indrawati, "Analysis of Scientific Literacy Ability Junior High School Students in Science Learning on Environmental Pollution," *Jurnal Penelitian Pendidikan IPA*, vol. 9, no. 3, pp. 1001–1005, 2023, doi: 10.29303/jppipa.v9i3.1816.
[41] S. Kijkuakul, "Teachers' perceptions on primary science teaching," *AIP Conference Proceedings*, 2018, vol. 1923, no. 1, doi: 10.1063/1.5019518.
[42] A. Markwick and M. J. Reiss, "Professional learning in primary science: developing teacher confidence to improve the leadership of teaching and learning," *International Journal of Science Education*, pp. 1–21, 2023, doi: 10.1080/09500693.2023.2288660.
[43] Setyaningsih, F. Roshayanti, N. Nizaruddin, and N. Khoiri, "Science Literacy Profile of Junior High School Students on Global Warming Material," *Lembaran Ilmu Kependidikan*, vol. 53, no. 1, pp. 120–130, 2024, doi: 10.15294/lik.v53i1.4661.
[44] T. Nuryanti, I. D. Pursitasari, and B. Rubini, "Science Literacy Profile of Junior High School Students on Climate Change Material," *Jurnal Penelitian Pendidikan IPA*, vol. 9, no. 10, pp. 8390–8395, 2023, doi: 10.29303/jppipa.v9i10.5218.
[45] OECD, *PISA 2018 Assessment and Analytical Framework*. Paris, French: OECD Publishing, 2019, doi: 10.1787/b25efab8-en.
[46] B. Bahtiar, I. Ibrahim, and M. Maimun, "Analysis of Students' Scientific Literacy Skill in terms of Gender Using Science Teaching Materials Discovery Model Assisted by PhET Simulation," *Jurnal Pendidikan IPA*, vol. 11, no. 3, pp. 371–386, 2022, doi: 10.15294/jpii.v11i3.37279.
[47] D. Lestari and W. Setyarsih, "Analysis of Students' Scientific Literacy Skills and The Relationship with Critical Thinking Skills on Global Warming Materials," *Journal of Physics: Conference Series*, vol. 1805, no. 1, pp. 012040, 2021, doi: 10.1088/1742-6596/1805/1/012040.
[48] S. Y. Sari, W. S. Dewi, and Asrizal, "Validity of science teaching aids based on project based learning," *Journal of Physics: Conference Series*, 2020, vol. 1481, no. 1, p. 012107, doi: 10.1088/1742-6596/1481/1/012107.
[49] Parno, L. Yuliati, and B. Q. A. Ni'mah, "The influence of PBL-STEM on students' problem-solving skills in the topic of optical instruments," *Journal of Physics: Conference Series*, vol. 1171, p. 012013, 2019, doi: 10.1088/1742-6596/1171/1/012013.
[50] P. D. Lestari and J. Mansyur, "The influence of the online PhET simulation-assisted using direct instruction on student's conceptual understanding of parabolic motion," *Journal of Physics: Conference Series*, 2021, vol. 2126, no. 1, p. 012013, doi: 10.1088/1742-6596/2126/1/012013.
[51] C. T. Dewi and R. S. N. Mahmudah, "Developing A Simple Parabolic Motion Props: Steps and Their Applicability," *Jurnal Pendidikan Fisika dan Keilmuan (JPFK)*, vol. 9, no. 1, pp. 31–44, 2023, doi: 10.25273/jpfk.v9i1.14385.
[52] S.-Y. Chen and S.-Y. Liu, "Reinforcement of Scientific Literacy through Effective Argumentation on an Energy-related Environmental Issue," *EURASIA Journal of Mathematics, Science and Technology Education*, vol. 14, no. 12, 2018, doi: 10.29333/ejmste/95171.
[53] I. Wilujeng, W. S. B. Dwandaru, and R. A. B. A. Rauf, "The Effectiveness of Education for Environmental Sustainable Development to Enhance Environmental Literacy in Science Education: A Case Study of Hydropower," *Jurnal Pendidikan IPA Indonesia*, vol. 8, no. 4, pp. 521–528, 2019, doi: 10.15294/jpii.v8i4.19948.
[54] V. Pletser, S. Rouquette, and U. Friedrich, "Two joint European partial-g parabolic flight campaigns for science and exploration at moon and mars gravity levels," *64th International Astronautical Congress*, 2013, pp. 1–14.
[55] F. Zahara and R. Afrizon, "Development physics worksheet integrated scientific literacy using a constructive approach on parabolic motion materials," *Pillar of Physics Education*, vol. 16, no. 1, pp. 50–58, 2023, doi: 10.24036/14230171074.
[56] S.-C. Yeh, J.-Y. Huang, and H.-C. Yu, "Analysis of Energy Literacy and Misconceptions of Junior High Students in Taiwan," *Sustainability*, vol. 9, no. 3, p. 423, 2017, doi: 10.3390/su9030423.
[57] A. Martins, M. Madaleno, and M. F. Dias, "Energy literacy: What is out there to know?," *Energy Reports*, vol. 6, pp. 454–459, 2020, doi: 10.1016/j.egyr.2019.09.007.
[58] O. S. Santillán and K. G. Cedano, "Energy Literacy: A Systematic Review of Scientific Literature," *Energies*, vol. 16, no. 21, p. 7235, 2023, doi: 10.3390/en16217235.

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