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STUDENT'S SCIENCE LITERACY SKILL THROUGH IMPLEMENTATION OF INTEGRATING TEACHING MODULES WITH SETS APPROACH ON RENEWABLE ENERGY TOPICS

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Abstract

This research aims to describe students' science literacy through implementation of integrating teaching modules with SETS approach on renewable energy topics. This research is a quantitative pre-experimental method with one-group pretest-post-test design with 34 research subjects in one of the high schools in Banjarmasin. The instrument used was a science literacy test in the form of an essay, consisting of four questions based on the dimensions of PISA science literacy. The study found that students' science literacy, based on statistical tests of pretest and post-test results, showed significant differences. The dimensions of science literacy that involve explaining scientific phenomena, interpreting data or scientific evidence, and the evaluation and design of scientific investigations were categorized as high in the post-test. Students' science literacy improved because the implementation of integrating the teaching module with SETS approach. This research is expected to be a guideline for other research in improving students' scientific literacy.

Keywords: PISA assessment, Renewable energy, Science literacy skill, SETS approach, Teaching module.

1. Introduction

The integration of teaching modules with the science, environment, technology, and society (SETS) approach significantly improves students' science literacy skills, especially in the context of renewable energy education. This educational strategy fosters critical thinking and is aligned with the sustainable development goals (SDGs), especially in promoting awareness and understanding of renewable energy sources among students.

Research shows that the incorporation of self-paced learning and innovative physics education within the SETS framework can substantially improve critical thinking skills among students [1-5]. This is especially important in the Society 5.0 era, where the integration of technology and education plays an important role in achieving the sustainable development goals by 2030 [6-10]. The SETS approach emphasizes the interconnectedness of science and social issues, allowing students to engage with real-world issues, especially those related to renewable energy and environmental sustainability.

In addition, the effectiveness of educational interventions in renewable energy topics is supported by findings that highlight a positive correlation between students' level of knowledge and their support for renewable energy policies [11-13]. Higher quiz scores related to renewable energy concepts were associated with a greater likelihood of advocating for such policies, suggesting that increased science literacy directly affects students' attitudes toward renewable energy [14-16]. This is in line with the idea that educational programs should not only provide knowledge but also foster a sense of responsibility and advocacy for sustainable practice.

The lack of public awareness of renewable energy sources is a significant barrier to the implementation of sustainable practices [17-19]. Educational initiatives focused on renewable energy can bridge this gap by increasing public understanding and acceptance of these technologies [20-23]. Research has shown that children educated about renewable energy are more likely to embrace these technologies as part of their lifestyles, thus fostering a generation of informed decision-makers and advocates for sustainable energy solutions [24-26].

In addition, the relationship between educators' attitudes towards renewable energy and the critical thinking disposition of their students underscores the importance of teacher training in this domain [27-29]. Teachers who are knowledgeable and positive about renewable energy are more likely to instil similar attitudes in their students, thereby improving the overall educational experience and promoting a culture of sustainability [30]. This is particularly relevant in the context of higher education, where the demand for skilled professionals in the renewable energy sector is increasing rapidly [31, 32]. In summary, the application of the integration of teaching modules with the SETS approach on renewable energy topics significantly improves students' science literacy skills. This approach not only fosters critical thinking and awareness of renewable energy but also prepares students to become proactive contributors to sustainable development. As educational institutions continue to evolve, an emphasis on renewable energy education will be crucial in shaping a more sustainable future.

Based on the above background, research was conducted on students' science literacy through the implementation of integrating the teaching module with SETS approach. The purpose of this research is to describe the achievement of students' science literacy through the implementation of integrating the teaching module SETS approach. The novelty of this research is (i) integrating the SETS approach in the teaching module on renewable energy topic; (ii) through the SETS approach, students are trained in scientific literacy skill. This research is expected to contribute to science literacy education. Finally, this study supports current issues in the sustainable development goals (SDGs) as reported elsewhere [33-37].

2. Literature Review

2.1. Renewable energy

Renewable energy is increasingly recognized as an important component of the global energy landscape, especially because of its potential to mitigate climate change, improve energy security, and drive sustainable economic growth. Renewable energy sources, such as wind, solar, geothermal, hydroelectric power, and biomass, are characterized by their ability to regenerate naturally and provide a sustainable alternative to fossil fuels, which are limited and contribute significantly to environmental degradation [38-40].

The transition to renewable energy is driven by several factors, including the urgent need to reduce greenhouse gas emissions and combat climate change. Reliance on fossil fuels has led to significant environmental challenges, including air pollution and climate instability. Instead, renewable energy sources offer cleaner alternatives that can help achieve global climate goals [41, 42]. For example, wind energy has been highlighted for its high productivity and reliability compared to other renewable sources, making it an important player in the energy transition [43].

2.1.1. Hydroelectric power plants

Hydroelectric power plants (HPP) are one of the most important sources of renewable energy around the world, utilizing the kinetic energy of flowing water to generate electricity. The technologies used in HPP vary, ranging from large dams to smaller river flow systems, all of which aim to convert mechanical energy into electrical energy. The operational efficiency of HPP is greatly influenced by hydrological conditions, which are increasingly vulnerable to climate change, thus causing variability in water availability and flow patterns [44-46].

The role of HPP in energy generation is particularly prominent in countries such as Brazil, where these plants account for around 59% of the total installed capacity [47]. HPP is in demand due to its lower greenhouse gas emissions compared to fossil fuel-based power plants, making it a key component in efforts to reduce carbon footprint [48]. However, dependence on hydropower also presents challenges, especially in areas prone to drought and climate variability, which can significantly affect electricity production [44, 45, 49]. The integration of wind energy with HPP has been proposed as a solution to reduce the impact of water flow variability, thus allowing for a more stable energy supply [47-49].

HPP utilizes the power of water to generate electricity in a sustainable and environmentally friendly manner. Through the utilization of potential energy stored in the water in the reservoir, HPP is able to convert this energy into kinetic energy and finally into electrical energy that can be used to meet the needs of the community. In the HPP scheme, various components such as reservoirs, penstocks, turbines, and generators work synergistically to ensure that the power generation process takes place efficiently and effectively. Figure 1 provides a clear picture of how the HPP system works, from water collection to electrical energy distribution, as well as the various essential elements that support its operational sustainability.

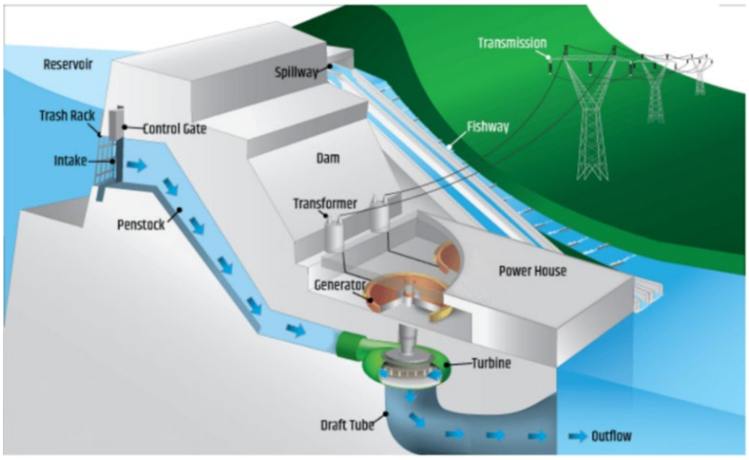


Fig. 1. Working principle of HPP [48].

Figure 1 shows a Hydroelectric Power Plant. HPP is an energy generation method that utilizes the potential energy of water from reservoirs. The water stored in the reservoir has potential energy due to its height. When water is flowed through the penstock, this potential energy is converted into kinetic energy. This high-speed water then spins the turbine, which converts kinetic energy into mechanical energy. The mechanical energy is then converted into electrical energy through a generator. The generated electricity is then transformed by the transformer to adjust to the required voltage before being distributed through the transmission network to the end user.

The hydropower plant is also equipped with a spillway to drain excess water from the reservoir to prevent damage to the dam and a fishway to allow fish to migrate through the dam. The water that has been used to rotate the turbine is flowed back into the river through a draft tube. This system is an efficient and environmentally friendly form of renewable energy, as it generates large amounts of electricity without direct carbon emissions, utilizing a stable and sustainable flow of water.

2.1.2. Solar cells

In recent decades, developments in solar cell technology have made it possible to increase efficiency and reduce production costs, making it an increasingly affordable and reliable energy solution for a wide range of applications, from household scale to large industrial scale. Figure 2 shows a visual representation of how solar cells work, illustrating the process of converting energy from sunlight into electricity that can be used for a variety of everyday purposes.

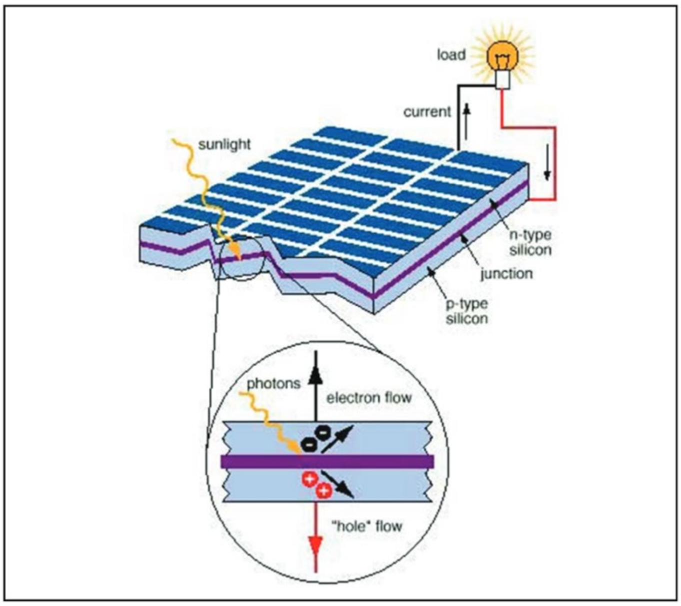


Fig. 2. Illustration of solar cells at work [50].

Figure 2 shows a diagram of a solar cell, which is the main device in a solar panel to convert solar energy into electrical energy. The working principle of solar cells is based on the photovoltaic effect, in which sunlight consisting of photons hits the surface of a solar cell made of a semiconductor material, generally silicon. Solar cells are made up of two different layers of silicon, which are n-type and p-type. When photons from sunlight are absorbed by this semiconductor material, the energy from the photons is enough to free the electrons from their atoms, creating electron-hole pairs.

These free electrons move towards the n-type layer, while the hole moves towards the p-type layer, creating a difference in electrical potential between the two layers [51]. The solar cell current (I_L) is directly proportional to the amount of solar radiation (G) and temperature (T) according to equation (4), where I_{SC} (T_{ref}) ISC (Tref) is the short circuit current of the solar cells at the reference temperature (Tref).

$$I_L = \frac{G}{G_{ref}} x(I_{sc}T_{ref} + K_i x \; (T - T_I) \qquad (1)$$

This potential difference causes the flow of electrons through an external circuit connected to the solar cell, which then generates an electric current. This electric current can be used to power a load such as a lamp, as shown in the diagram. In other words, solar cells convert light energy into electrical energy that can be used directly. This process is highly efficient and environmentally friendly, making solar energy one of the most promising renewable energy sources in the future. Solar cells do not require fuel and produce no emissions during their operation, thus contributing to the reduction of carbon footprint and climate change mitigation. The use of solar cells has additional advantages for developing countries due to their flexibility, cost competitiveness, and higher electrical output, along with recent technological innovations [52].

2.2. Science literacy

The term scientific literacy has the objectives of understanding and justifying the application of science in education [53]. Many reports relating to science literacy have been well documented [54-57]. Furthermore, there are various definitions of scientific literacy, namely: (i) understanding how science works: understanding the standards, methods, and processes associated with science [58, 59]; (ii) the ability to use scientific knowledge for personal, social, and cultural and civic purposes [58, 60]; (iii) making informed decisions about the natural world, moral and ethical justification [58, 60]; (iv) understanding the collective nature of science [58, 61]; and (v) the ability to critically evaluate scientific information and arguments made by scientists or the media [58, 62].

Another definition of scientific literacy is the ability to participate in addressing scientific problems and ideas by using what is known to identify questions, generate new knowledge, provide scientific explanations, and develop reflective thinking patterns [63, 64]. People who are scientifically literate need competencies, namely the competence to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence scientifically [65]. Based on this definition, scientific literacy can be defined as a series of abilities or self-skills that make science the main reference in solving various scientific problem ideas.

Framework for PISA 2022 science literacy assessment same as PISA for 2018, namely (i) the dimension of science competence; (ii) the dimension of knowledge or science core; (iii) the dimension of the context of science use; (iv) the dimension of the attitude. Specifically, the science competencies dimension relates to explaining scientific phenomena, interpreting data or scientific evidence, and evaluating and designing scientific investigations [63]. The science knowledge dimension relates to content, procedural, and epistemic knowledge. Finally, the science context dimension relates to personal, local/national, and global needs [63]. Figure 3 shows the framework for PISA 2022.

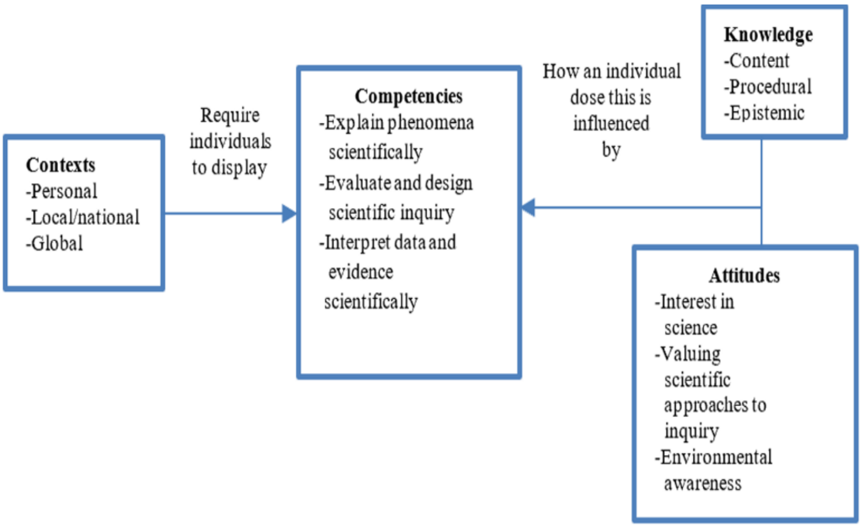


Fig. 3. Framework for PISA 2022 scientific literacy assessment [63].

2.3. Sciences, environment, technology, and society (SETS)

In the era of increasingly complex globalization, education has a crucial role in shaping individuals who are not only academically intelligent, but also sensitive to global challenges and issues. A holistic and integrated approach to education is becoming increasingly important to ensure that students not only acquire theoretical knowledge but are also able to apply it in real-life contexts. One framework that emphasizes this approach is the integration of science, technology, the environment, and society in the educational curriculum. This framework teaches students to understand how each of these elements is interrelated and affects each other, as well as how they can work together to achieve sustainable and responsible solutions. The following Fig. 4 illustrates how these four elements come together in the context of education, demonstrating the importance of interdisciplinary understanding in creating meaningful and relevant learning for students in the 21st century.

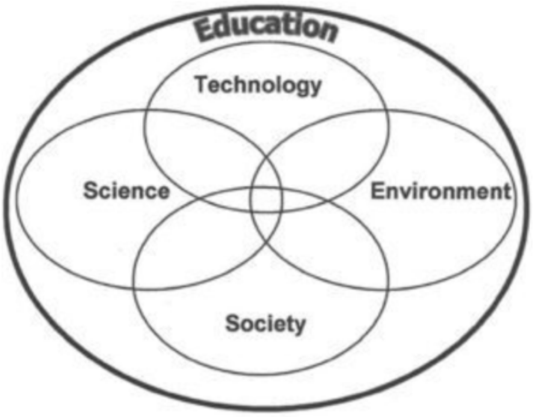


Fig. 4. Science-environment-technology-society (SETS) framework for research and education for sustainability [66, 67].

Figure 4 is a representation of a holistic approach to education, which integrates four main elements: science, technology, environment, and society. At its core, this approach suggests that education is inseparable from the broader context in which science, technology, the environment, and society interact with each other and influence each other. Each of these elements has an important role in shaping a more comprehensive and in-depth understanding of the world around us. For example, science provides the basis of knowledge, technology facilitates the application of that knowledge, the environment becomes the context in which we apply and observe the results, and society provides values and perspectives that guide how science and technology are used.

The interaction between science, the environment, technology, and society is a complex and diverse domain that has attracted significant attention in recent years. This review synthesizes various perspectives on how technological advances can positively and negatively affect environmental sustainability and community well-being. One of the central themes in this discourse is the evaluation of the role of technology in promoting sustainability. A comprehensive framework for assessing the impact of technology on the environment and society, highlighting the interaction between technology, economics, and ecological systems [66]. This framework is crucial because it moves beyond a simple view of technology as a benefit or harm, rather than advocating for nuanced understandings that combine economic, social, and environmental dimensions. The dual nature of technology development, notes that although traditional industrialization often leads to environmental degradation, the emergence of green technology presents an opportunity to create a more resilient global society [68].

The philosophical basis of the impact of technology on society is also explored in this discourse. The technogenic environment through various lenses-technocentric, ecocentric, and anthropocentric—each reveals different aspects of how technology shapes social interactions and environmental outcomes [69]. This classification underscores the importance of adopting a holistic view when assessing the impact of technology, as it allows for a more integrated approach to understanding the consequences of technological innovation. The concept of Society 5.0, which reflects the vision of a future where technology is utilized to overcome social challenges and improve human capabilities. This vision is in line with the SDGs, which emphasize the need for technological innovation to support sustainable development [70]. Disruptive technologies with the achievement of the SDGs, show that a coordinated approach to technology development is essential to realize sustainable outcomes [71].

2.4. Teaching module

Teaching module theory involves a structured educational approach that emphasizes the use of separate, independent units of instruction, known as modules. This method allows for the systematic development of skills and knowledge, offering a more personalized learning experience for students. The modular approach is particularly effective in accommodating diverse learning styles and paces, allowing students to engage with content at their own pace while fostering independence in their learning journey [72-73]. By breaking down the content into manageable sections, students can focus more on specific areas of learning, which can lead to increased retention and understanding.

The theoretical framework underlying the teaching module is essential for its effectiveness. A well-designed module should incorporate essential elements such as relevant content, applicable theory, effective teaching design, and material that undergoes formative evaluation to ensure its usefulness in an educational setting [74-75]. For example, integrating theories of social interdependence and operant conditioning can improve the learning experience by promoting collaborative learning and reinforcing positive behaviour's [75]. In addition, ADDIE's instructional design model (analysis, design, development, implementation, evaluation) is often used to guide the creation of educational modules, ensuring they meet specific learning objectives and meet the needs of learners [76]. This structured approach ensures that modules are not only educationally sound but also adaptable to a variety of learning contexts, including digital and interactive platforms, which have become well-known in recent years [74-77]. Table 1 shows several teaching modules developed using ADDIE's instructional design model with the SETS approach [78-80].

Table 1. Teaching modules developed using the SETS approach.

No.	Title	Ref.
1	Development of SETS e-module integrated with POE model for science learning.	[78]
2	EM-SETS: An integrated e-module of environmental education and technology in natural science learning.	[79]
3	The influence of SETS based e-modules on scientific literacy using the discovery learning model	[80]

3. Method

This research method is quantitative pre-experimental. The research design employs a one-group pretest-post-test design. The implementation of integrating the teaching module with SETS approach was carried out with 34 students at a high school in Banjarmasin. The research subjects were selected using purposive sampling. Before the implementation of the teaching module, students first took a pretest. After the implementation of the teaching module, students took a posttest. The improvement in students' science literacy was analysed based on the results of the pretest and post-test analysis. The components of science literacy used refer to the PISA science literacy components [63].

The data for this study was collected using an essay test. The test consisted of four questions, aligned with the PISA science literacy components. The effectiveness of students' science literacy achievement was analysed using the non-parametric Mann-Whitney statistical test, as the normality test results indicated that the pretest and post-test data were not normally distributed. To measure the level of students' science literacy achievement [81].

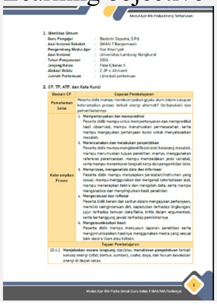
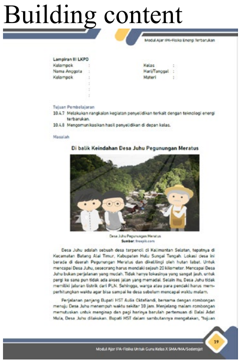
4. Results and Discussion

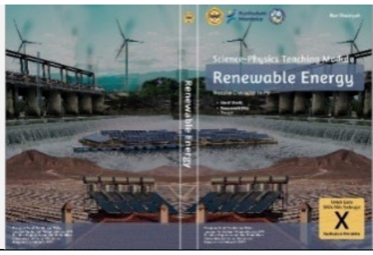
The objective of this research is to describe the science literacy of students after the implementation of integrating the teaching module with SETS approach. The teaching module was validated by five experts. (four lecturers and one practitioner). The results of the development of integrating the teaching module with SETS approach teaching module with ADDIE instructional design model are presented in Table 2.

The following is a review of the science literacy dimension of explaining phenomena scientifically. Figure 5(a) shows the questions on the science literacy dimension of explaining phenomena scientifically, and Fig. 5(b) shows a representative student answer from the post-test.

The question in Fig. 5(a) requires students to make or justify accurate predictions using knowledge of scientific concepts. Students need to read the information in the stimulus about the hydroelectric power plant, then answer the two questions. In this question, students must apply content knowledge by using the competence "explaining phenomena scientifically." The context is categorized as natural resources within a local/national scope. Solving the question requires the use and application of conceptual knowledge.

Table 2. Development of teaching module with SETS approach.

Stage	Procedure	Result
Analysed	Case study of education problems in Indonesia*. Field study through interviews with relevant sources (teachers)*, problems found; school curriculum; student characteristics; and learning tools	Conclusion of analysis: development of teaching modules is needed to improve students' scientific literacy using the SETS approach on the topic of renewable energy.
Design	Determining learning objectives based on learning outcomes Creating a module flowchart Compiling a module draft Creating a testing strategy	Learning objective 
Development	Building content Selecting or developing supporting media Developing guides for teachers and students Conducting expert validation Conducting formative revisions	Building content  Expert validation results: CVR = 0.99 Reliability = 0.98
Evaluation	Assess the quality of learning processes and products before and after implementation	Final Product



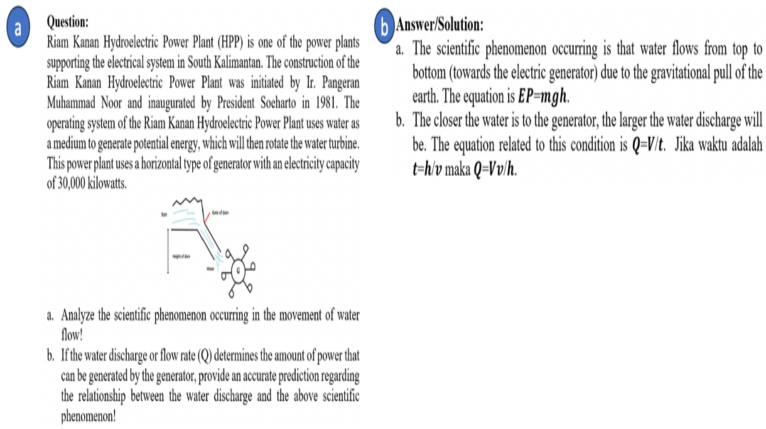


Fig. 5. (a). Question on the dimension of explaining phenomena scientifically, (b). Student representative answer in the post-test.

Students' pretest answers were low on this question because they lacked an understanding of the scientific phenomenon occurring, so they could not make a prediction. After students participated in learning that systematically trained science literacy by the teacher, the post-test results were categorized as high. Moreover, the students' predictions in question 1.b were supported by the reinforcement of the water discharge equation, unlike in the pretest where students did not include argument reinforcement.

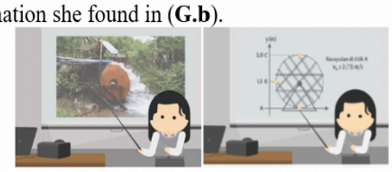
The following is a review of the science literacy dimension of interpreting data and evidence scientifically in the pretest and post-test. Figure 6(a) shows the question on the science literacy dimension of interpreting data and evidence scientifically, and Fig. 6(b) shows the student's answer in the post-test.

The question in Fig. 6(a) requires students to explore their understanding of data. Students are asked to read the stimulus about the micro-hydro power plant and analysed the energy changes in the water wheel into a graphical form. This question tests content knowledge using the competence "interpreting data and evidence scientifically". The context is natural resources within a local/national scope.

Student responses were low in the pretest because they were unable to argue based on the information. This competence requires more than just reading data, translating it, and then presenting it; students must also be able to package their arguments by interpreting information with appropriate representation. Figure 6(b). is representative the student's answer in the post-test. In the post-test results, some students were able to read data, translating it, and present information with appropriate representation.

a **Question:**

Eva shares that she once visited a micro-hydro power plant (MHPP) unit located in Kintap Subdistrict, Tanah Laut Regency, South Kalimantan. The Kintap MHPP is managed directly by the local residents and can generate 900 watts of electricity by utilizing the water flow from a lake along an old mining excavation (**G.a**). Eva also detailed other information she found in (**G.b**).

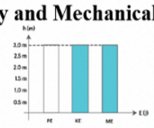


a. **b.**

If Eva wants to analyze the energy changes that occur in the water wheel, create a bar chart showing the kinetic energy, potential energy, and mechanical energy of the water along with an analysis statement of the condition!

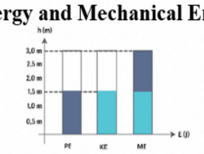
b **Answer**

Kinetic Energy, Potential Energy and Mechanical Energy diagram at point A



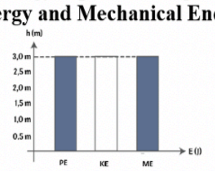
At point A above the water surface, potential energy = 0. Mechanical energy at point A = kinetic energy at point A.

Kinetic Energy, Potential Energy and Mechanical Energy diagram at point B



At point B in the middle of the water wheel, there is potential energy. Mechanical energy at point B = the sum of kinetic energy at point B and potential energy at point B.

Kinetic Energy, Potential Energy and Mechanical Energy diagram at point C



At point C above the water wheel, kinetic energy = 0. Mechanical energy at point C = potential energy at point C.

Fig. 6. (a) Question for the dimension of interpreting data and evidence scientifically, (b) Representation of student responses in the post-test.

Below is an explanation of the dimension of science literacy in interpreting data and evidence scientifically. Figure 7(a) question for the dimension of science literacy in interpreting data and evidence scientifically. Figure 7(b) a representative student answer in the post-test.

The question in Fig. 7(a) requires students to explore their understanding of data. Students are asked to read a stimulus about a solar water heater and analysed the number and area of solar collectors needed for a bathing room. This question tests content knowledge using the competency of "interpreting data and evidence scientifically." The context is categorized as natural resources within a local/national scope.

(a)

Question:

Banjarmasin is a densely populated city in South Kalimantan. According to the 2018 Second Semester Population Report issued by the Directorate General of Population and Civil Registration of South Kalimantan Province, most of Banjarmasin's residents work in private offices and government positions (civil servants). To access a peaceful, rural vacation spot like the Tanuhi Hot Springs in Loksado, Banjarmasin residents need to dig deep into their wallets and consider their work schedules. Moreover, this tourist spot is the only one in South Kalimantan that offers hot spring facilities because the island of Kalimantan is not located along the Pacific Ring of Fire, and therefore lacks active volcanoes that could provide geothermal resources.

Given this situation, the Banjarmasin local government should open business and research opportunities by utilizing technological advancements such as solar water heaters, transforming small areas of Banjarmasin into enclosed hot spring facilities. This would help residents relax without worrying about costs and work demands. To realize this development, one of the actions that Bappeda (Regional Development Planning Agency) should take is to gather information related to the size of the bathing area, the amount of water in the bathing area, the water temperature, the efficiency of the solar collectors, the price of the solar collectors, and the intensity of solar radiation falling on the surface of the solar collectors.

Note: Specific Heat Capacity: 4,200 joule/kg°C.

Price of Solar Collector: IDR 700,000 (2 × 3) m.

Bathing Area			Solar Water Heater	
Area	Water Volume	Water Temperature	Solar Radiation Intensity	Collector Efficiency
5x5 m	1,000 L	20°C-40°C	600 W/m²	85%
6x7 m	1,400 L	20°C-50°C	600 W/m²	85%

For a target water heating time of approximately ±8 hours, determine the number and area of solar collectors required for one bathing room! (Water density ρ= 1.000 kg/m3).

(b)

Answer/Solution:

Given:

- c = 4,200joules/kg°C
- Price of solar collector, IDR 700,000.00 for a size of (2×3) m or 6 m²
- ρ=1,000 kg/m³
- VA=1,000 L = 1,000 dm³ = 1 m³
- VB=1,400 L = 1,400 dm³ = 1.4 m³
- mA=ρVA=1,000 kg
- mB= ρVB=1,400 kg ΔTA=(40−20)°C=20°C
- ΔTB=(50−20)°C=30°C
- η=85% or 0.85
- IR=600W/m²
- t= 8 hours = 8×3,600 s=28,800 s

Question: What is the required number and area of solar collectors?

Answer/Solution:

Areas of collectors needed to heat **1,000 L** of water from **20**°C−**40**°C

$$A_A = \frac{mAc\Delta TA}{\eta IRt} = \frac{(1{,}000\ kg)(4{,}200 joule/\ kg°C\ )(20°C)}{(0.85)(600W/m^2\ )(28{,}800\ s)} = \frac{(1{,}000\ kg)(4{,}200 joule/\ kg°C\ )(20°C)}{(0{,}85)(600 joule/m^2 s\ )(28{,}800\ s)}$$

A_A=5.72 m² atau 6 m²

Area of collectors needed to heat **1,400 L** of water from **20**°C−**50**°C

$$A_B = \frac{mBc\Delta TB}{\eta IRt} = \frac{(1{,}400\ kg)(4{,}200 joule/kg°C\ )(30°C)}{(0.85)(600W/m^2)(28{,}800\ s)} = \frac{(1{,}400\ kg)(4{,}200 joule\ kg°C\ /\ )(30°C)}{(0.85)(600 joule/m^2 s\ )(28{,}800\ s)}$$

A_B=12 m²

Conclusion: For a bathing room with a water volume of 1,000 L, a solar collector area of 6 m² is required. Therefore, only one solar collector, costing IDR 700,000, needs to be purchased. For a bathing room with a water volume of 1,400 L, a solar collector area of 12 m² is necessary. Hence, two combined solar collectors, costing IDR 1,400,000, should be purchased.

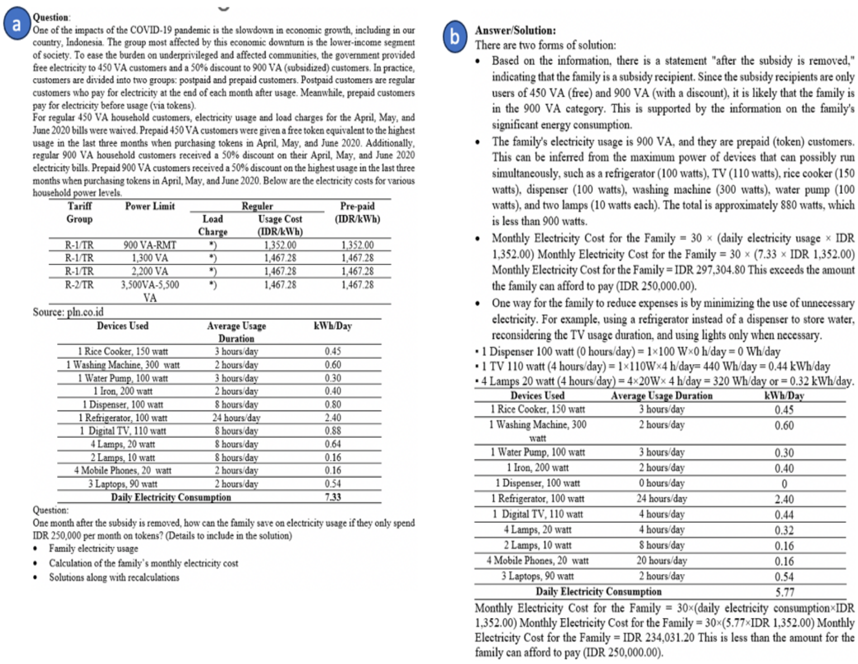
Fig. 7. (a) Question for the dimension of interpreting data and evidence scientifically, (b) Student representative answer in the post-test.

Students' answers were low on the pretest because they were unable to link arguments to the information provided. In this competency, it is not just about reading data, translating it, and presenting it; students must also be able to frame their arguments by interpreting information with appropriate representation. In the post-test results, students were able to frame information with appropriate representation.

The following is an explanation of the science literacy dimension of evaluating and designing scientific investigations. Figure 8(a) shows a question for the dimension of evaluating and designing scientific investigations, and Fig. 8(b) shows representative answers from students on the post-test.

The question in Fig. 8(a) requires students to evaluate and design a scientific investigation. Students are asked to design a way to save PLN electricity in households. The knowledge categorization for this item is procedural, and the competency is to evaluate and design scientific investigations. The context is categorized as Natural Resources within a local/national scope. The cognitive level of this question is categorized as high because students are given a complex situation and need to develop a systematic investigation order to answer the question.

Students' answers were low on the pretest because they were able to determine the family's electricity usage rate but were unable to evaluate the design of the electricity-saving method by arguing why that particular rate should be used. Figure 8(b) shows presentative answer on the post-test. In the post-test results, some students evaluated the electricity-saving method design and provided arguments. In addition, students' solutions for item four were supported by information references related to the family's electricity usage rate and solutions in the form of mathematical analysis.



a

Question:

One of the impacts of the COVID-19 pandemic is the slowdown in economic growth, including in our country, Indonesia. The group most affected by this economic downturn is the lower-income segment of society. To ease the burden on underprivileged and affected communities, the government provided free electricity to 450 VA customers and a 50% discount to 900 VA (subsidized) customers. In practice, customers are divided into two groups: postpaid and prepaid customers. Postpaid customers are regular customers who pay for electricity at the end of each month after usage. Meanwhile, prepaid customers pay for electricity before usage (via tokens).

For regular 450 VA household customers, electricity usage and load charges for the April, May, and June 2020 bills were waived. Prepaid 450 VA customers were given a free token equivalent to the highest usage in the last three months when purchasing tokens in April, May, and June 2020. Additionally, regular 900 VA household customers received a 50% discount on their April, May, and June 2020 electricity bills. Prepaid 900 VA customers received a 50% discount on the highest usage in the last three months when purchasing tokens in April, May, and June 2020. Below are the electricity costs for various household power levels.

Tariff Group	Power Limit	Reguler		Pre-paid (IDR/kWh)
		Load Charge	Usage Cost (IDR/kWh)	
R-1/TR	900 VA-RMT	*)	1,352.00	1,352.00
R-1/TR	1,300 VA	*)	1,467.28	1,467.28
R-1/TR	2,200 VA	*)	1,467.28	1,467.28
R-2/TR	3,500VA-5,500 VA	*)	1,467.28	1,467.28

Source: pln.co.id

Devices Used	Average Usage Duration	kWh/Day
1 Rice Cooker, 150 watt	3 hours/day	0.45
1 Washing Machine, 300 watt	2 hours/day	0.60
1 Water Pump, 100 watt	3 hours/day	0.30
1 Iron, 200 watt	2 hours/day	0.40
1 Dispenser, 100 watt	8 hours/day	0.80
1 Refrigerator, 100 watt	24 hours/day	2.40
1 Digital TV, 110 watt	8 hours/day	0.88
4 Lamps, 20 watt	8 hours/day	0.64
2 Lamps, 10 watt	8 hours/day	0.16
4 Mobile Phones, 20 watt	2 hours/day	0.16
3 Laptops, 90 watt	2 hours/day	0.54
Daily Electricity Consumption		**7.33**

Question:

One month after the subsidy is removed, how can the family save on electricity usage if they only spend IDR 250,000 per month on tokens? (Details to include in the solution)

- Family electricity usage
- Calculation of the family's monthly electricity cost
- Solutions along with recalculations

b

Answer/Solution:

There are two forms of solution:

- Based on the information, there is a statement "after the subsidy is removed," indicating that the family is a subsidy recipient. Since the subsidy recipients are only users of 450 VA (free) and 900 VA (with a discount), it is likely that the family is in the 900 VA category. This is supported by the information on the family's significant energy consumption.
- The family's electricity usage is 900 VA, and they are prepaid (token) customers. This can be inferred from the maximum power of devices that can possibly run simultaneously, such as a refrigerator (100 watts), TV (110 watts), rice cooker (150 watts), dispenser (100 watts), washing machine (300 watts), water pump (100 watts), and two lamps (10 watts each). The total is approximately 880 watts, which is less than 900 watts.
- Monthly Electricity Cost for the Family = 30 × (daily electricity usage × IDR 1,352.00) Monthly Electricity Cost for the Family = 30 × (7.33 × IDR 1,352.00) Monthly Electricity Cost for the Family = IDR 297,304.80 This exceeds the amount the family can afford to pay (IDR 250,000.00).
- One way for the family to reduce expenses is by minimizing the use of unnecessary electricity. For example, using a refrigerator instead of a dispenser to store water, reconsidering the TV usage duration, and using lights only when necessary.

• 1 Dispenser 100 watt (0 hours/day) = 1×100 W×0 h/day = 0 Wh/day
• 1 TV 110 watt (4 hours/day) = 1×110W×4 h/day= 440 Wh/day = 0.44 kWh/day
• 4 Lamps 20 watt (4 hours/day) = 4×20W× 4 h/day = 320 Wh/day or = 0.32 kWh/day.

Devices Used	Average Usage Duration	kWh/Day
1 Rice Cooker, 150 watt	3 hours/day	0.45
1 Washing Machine, 300 watt	2 hours/day	0.60
1 Water Pump, 100 watt	3 hours/day	0.30
1 Iron, 200 watt	2 hours/day	0.40
1 Dispenser, 100 watt	0 hours/day	0
1 Refrigerator, 100 watt	24 hours/day	2.40
1 Digital TV, 110 watt	4 hours/day	0.44
4 Lamps, 20 watt	4 hours/day	0.32
2 Lamps, 10 watt	8 hours/day	0.16
4 Mobile Phones, 20 watt	20 hours/day	0.16
3 Laptops, 90 watt	2 hours/day	0.54
Daily Electricity Consumption		5.77

Monthly Electricity Cost for the Family = 30×(daily electricity consumption×IDR 1,352.00) Monthly Electricity Cost for the Family = 30×(5.77×IDR 1,352.00) Monthly Electricity Cost for the Family = IDR 234,031.20 This is less than the amount for the family can afford to pay (IDR 250,000.00).

Fig. 8. (a) Questions on the dimension of evaluating and designing scientific investigations, (b) Student representative answer in the post-test.

The achievement of students' science literacy based on the dimensions of science ability varies. Table 3 presents the achievement of science ability dimensions based on pretest and post-test results.

Table 3. Achievement of science literacy dimensions.

Science Literacy Dimensions	Average Score			
	Pre-test	Category	Post-test	Category
Explaining phenomena scientifically	21.02	Low	78.13	High
Interpreting data and evidence scientifically	25.00	Low	75.98	High
Evaluating and designing scientific investigations	10.94	Low	68.44	High
Average	16.97	Low	74.18	High

Based on Table 3, each dimension of science literacy in the post-test results increased compared to the pretest results. From the pretest results, the largest science literacy dimension was explaining phenomena scientifically, and the smallest was evaluating and designing scientific investigations. The pretest results for all science literacy dimensions were categorized as low. From the post-test results, the largest science literacy dimension was explaining scientific phenomena, and the smallest was evaluating and designing scientific investigations. The post-test results for all science literacy dimensions were categorized as high.

The dimension of scientific literacy related to explaining scientific phenomena showed high performance on the post-test. The ability to explain phenomena scientifically requires students to recall substantial scientific knowledge or content in specific situations and use it to interpret and provide explanations related to scientific phenomena, as well as to make predictions or tentative hypotheses [63]. Students with scientific literacy are expected to use standard scientific models to create simple representations to explain everyday phenomena. This competence also includes the ability to describe or interpret phenomena and predict potential changes and implications in the social environment [54, 63, 82, 83].

Another dimension that scored high is the ability to interpret data or scientific evidence. The ability to interpret data and evidence scientifically requires students to convey their arguments by interpreting data or information with appropriate representations. These representations can be in the form of writing, diagrams, design drawings, or mathematical equations. A scientifically literate person must be able to interpret the meaning of scientific evidence and its implications in their own words, using diagrams or other appropriate representations. This competence also includes accessing scientific information, generating and evaluating arguments or conclusions based on scientific evidence, and providing reasoning using procedural or epistemic knowledge [54, 63, 82, 83].

The dimension that scored high is the ability to evaluate and design scientific investigations. Competence in evaluating and designing scientific investigations is necessary to evaluate scientific reports and investigate critically. This competence depends on the ability to distinguish scientific questions from other types of questions or recognize questions that can be investigated scientifically in a specific context. It requires knowledge of key features of scientific investigations, such as what to measure, which variables to change or control, or what actions to take to collect accurate and reliable data [54, 63, 82, 83].

Statistical tests were used to analyse the achievement of science literacy components. The results of the statistical tests are presented in Table 4.

Table 4. Statistical tests results for the achievement of science literacy.

Results	Mean	Normality Test	Difference Test (Sig. (2-tailed)
Pretest	16.97	0.036	0.000
Posttest	73.51	0.020	

Table 4 shows that the pre-test and post-test results based on the statistical tests differ significantly, indicating that the average post-test score increased compared to the pretest score. This is due to the implementation of the teaching module integrated through the SETS approach. Several studies have shown that the implementation of teaching modules with the SETS approach has a positive effect on various thinking skills and students' science literacy [78 ,79, 84-86]. The SETS-based teaching module science literacy through scientific texts. Students understand these texts and use the information to complete specific tasks [65, 87-89].

The presence of SETS in the teaching module elevates students' abilities to a multidimensional level, diversifying their knowledge of science content. The SETS approach is a learning process that focuses on real-world problems related to the components of science, environment, technology, and society from the perspective of the students, involving concepts and processes to reach the stages of investigation, analysis, and application [78, 79, 86]. The characteristics of the SETS approach in the learning process are (i) teaching science contextually; (ii) requiring thinking skills related to the transfer of science into technology; (iii) bringing situations that utilize science for community life; (iv) considering the benefits and drawbacks of using science related to relevant technology; (v) explaining the relationship of science to other SETS elements; and (vi) building an understanding of SETS from various individual initial perspectives [86]. This can address motivation issues, education quality problems, and the development of science literacy [87-89].

5. Conclusions

Based on the research results, students' scientific literacy improved significantly through the implementation of teaching modules using the SETS approach, according to statistical tests on pretest and post-test results. The dimensions of scientific literacy in explaining scientific phenomena, interpreting data or scientific evidence, and evaluating and designing scientific investigations were categorized as high on the post-test. Based on these findings, it can be concluded that students' scientific literacy increased after implementing of integrating the teaching module with SETS approach. This research had limitations, as it was conducted during a limited trial phase and focused on the topic of Renewable Energy. Future research could be implemented on a broader scale and with other topics in the Independent Curriculum.

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