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(RESEARCH ARTICLE)

The learning activities of RBL-STEM: Prototyping a water-powered lamp to enhance students' climate change literacy

Ike Khusniyawati [1,*], Dafik [2] and A. A. Ketut Budiastra [1]

[1] *Department of Postgraduate in Elementary Education, Universitas Terbuka, Indonesia.*
[2] *Department of Mathematics, University of Jember, Indonesia.*

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Abstract

Addressing climate change and the finite nature of fossil fuels necessitates proactive solutions, one of which is embedding climate change literacy within educational frameworks. This form of literacy aims to equip students with a comprehensive understanding of the concepts, causes, impacts, and potential solutions related to climate change. An educational approach that integrates these elements is the RBL-STEM learning model, particularly through the study of Renewable Energy. For instance, students engage in practical activities like constructing simple water-powered lights, which helps con textualize energy availability issues. This developmental research employed the 4D model to create and refine teaching modules, student worksheets (LKPD), and assessments for climate change literacy. The effectiveness of these materials was evaluated with a cohort of 25 fourth-grade students at SDN Tenggilis Mejoyo I in Surabaya. The findings indicated that the RBL-STEM learning resources related to Renewable Energy were well-designed, effective, and suitable for educational use. Importantly, they significantly enhanced the students' understanding and literacy regarding climate change, demonstrating the value of integrating hands-on, practical learning experiences in the curriculum to foster a deeper awareness and knowledge of renewable energy and climate-related issues.

Keywords: Learning Materials; RBL-STEM; Water-Powered Light Creation; Climate Change Literacy

1. Introduction

Climate change, now a global issue, continues to draw the attention of people worldwide. According to Law No. 31 of 2009 on Meteorology, Climatology, and Geophysics, climate change is indicated by changes in land temperatures, extreme increases in rainfall, delayed rainy seasons, and reduced rainfall volumes compared to average weather conditions. This is also caused by human activities through the continuous use and processing of the environment without balanced conservation efforts. As a result, the environmental damage that occurs has large-scale impacts affecting conditions and life on Earth, including in the areas of the environment, health, economy, clean water needs, and so forth [3, 4].

Fossil fuels, which are one of the causes of climate change on Earth but also act as a primary source in meeting human needs, are increasingly depleting. Therefore, efforts are needed to solve this through the replacement of energy sources with more sustainable and environmentally friendly alternatives. This effort can be undertaken through the provision of renewable alternative energy that refers to all energy that can replace conventional fuels (fuels derived from fossil energy). The intended energy sources include wind, water, and solar, which are considered to have high availability, both in supply and processing technology [12]. This step is taken as a response to climate change, both as an adaptation measure to reduce the impacts of climate change and as a mitigation action to address the causes of climate change [1].

* Corresponding author: Ike Khusniyawati

Efforts to address climate change can also be made through education by implementing climate literacy. This literacy provides an understanding of climate change adaptation and mitigation actions that can influence society to address it through environmental improvements, cleaner air, and leading to better economic growth [13]. Indicators in this literacy include understanding the concept of climate change, its causes, possible solutions, the ability to communicate, conduct research, and awareness of the impacts of climate change. This combination of knowledge, attitudes, and actions can be applied by students to effectively respond to the challenges and impacts of climate change, whether past, present, or future. Through science, students can understand concepts about themselves and their environment, including climate change not just theoretically, but by linking lesson material and real experiences, thus involving a real process of thinking and feeling in understanding the universe [4].

A learning model that can fully accommodate the aspects of climate change literacy is one oriented towards critical thinking skills, problem-solving, and creating projects or products as concrete actions for problem-solving. One such learning model that can be employed to enhance climate change literacy is the RBL-STEM model. This model is oriented around RBL (Research Based Learning) using a STEM (Science, Technology, Engineering, and Mathematics) approach that encourages students to actively discover their own knowledge through real experiences [15]. Through the RBL model, students can develop cognitive processes and independence through a mindset like a scientist (researcher) due to the orientation of the research process in learning [5]. The implementation of this model also has benefits, such as increased learning motivation, skill in solving complex problems, and active student participation that allows for interactivity and cooperation, making the learning process more comfortable [18].

The STEM approach is a key to integrating and continuously applying knowledge from several disciplines as an action to solve problems [9]. This approach encourages students to apply a mindset of sustainable development, especially in the context of climate change, so that students are expected to become part of a prosperous society, both economically and in the environmental conditions around them [6].

The implementation of RBL-STEM-based learning has also been applied in Indonesia. Moreover, this learning emphasizes the aspect of higher-order thinking skills (HOTS), which is an educational orientation in Indonesia to face challenges in the era of technological development. The proposed research focuses on the topic of renewable energy within the scope of utilizing water energy in daily life. Students will identify problems related to the phenomenon of fossil energy, which is becoming increasingly scarce, and how the use of renewable energy, in this case, water energy, acts as a problem-solving measure. This utilization of renewable energy is carried out through the creation of a simple water-powered lamp [7, 8].

The water-powered lamp creation is a simple miniature that adapts the working method of a hydroelectric power station in generating electrical energy. This creation has a system that receives water flow and moves it through a turbine equipped with a generator to convert the kinetic energy in the water into electrical energy that can power a lamp. The creation of this lamp also uses recycled materials, making it clean, economical, and environmentally friendly.

Creating this lamp requires learning materials that can accommodate systematic learning, so that the achievements and learning goals obtained by students can be optimal. The learning materials developed in this study include teaching modules, teaching materials, learning media, LKPD, and THPD [10, 14]. The scope of the material to be used is the science subject for fourth grade elementary school on the topic of renewable energy. The focus topic to be discussed is the utilization of water energy in daily life. These learning materials can encourage students to enhance their climate change literacy related to ongoing climate change issues, causes, and sustainable impacts, as well as possible solutions. In addition, students are also directed to make problem-solving steps through the creation of water-powered lamps as a concrete action of using water energy in life. Thus, students will have climate change literacy and problem-solving skills that will be useful to tackle problems in everyday life.

The aim of this research is to enhance students' climate change literacy to address issues of renewable energy through the creation of a simple water-powered lamp.

2. Research Methods

This study is a developmental research that uses the 4D Thiagarajan model, divided into the Define, Design, Develop, and Disseminate stages [19]. Developmental research is a method used to produce and test the effectiveness of a product [17]. The 4D model was chosen based on the practicality of the sequence of stages in developing learning materials with expert validation.

This research was conducted at SDN Tenggilis Mejoyo I Surabaya in the 2023/2024 academic year during the odd semester. Previously, the researcher conducted a feasibility validation of the learning materials with experts for implementation in the study.

The data obtained in this study are both quantitative and qualitative. Quantitative data were obtained based on the validation results of the learning materials by experts, the average results of student tests in completing LKPD (Student Worksheets) and climate change literacy tests, and the results of student response questionnaires in using LKPD or teaching media. Meanwhile, qualitative data were obtained from expert input regarding the feasibility of the learning materials, and data from observations while students used the LKPD or teaching media.

In the data collection process, instruments such as expert validation sheets, LKPD (Student Worksheet), climate change test sheets, student response questionnaires, and observation sheets are required. The validation sheets and questionnaires use a Likert scale and include open-ended questions to gather expert advice and student perceptions as users.

The data analysis techniques employed include descriptive analysis for both quantitative and qualitative data, and statistical analysis of student test results [11]. The data from the student tests, derived from the climate change literacy tests, are calculated and analyzed using a t-test, which is then compared with the KKTP (Learning Objective Completion Criteria) to determine the effectiveness of the learning materials in enhancing the climate change literacy of fourth-grade students at SDN Tenggilis Mejoyo I Surabaya.

3. Results

3.1. Learning Stages with the RBL-STEM Model

To enhance students' climate change literacy abilities, the focus of this research is the use of recycled materials to create water-powered lamps. This study is oriented towards learning that uses the RBL-STEM model.

The RBL-STEM model used in this research has a content context related to climate change through the subject of renewable energy in the fourth-grade science curriculum. Students are the main subjects in the learning process, while teachers act as motivators and guides for the students, allowing them to develop their abilities independently and optimally. The implementation of this learning in the context of climate change aims to: 1) Enhance the meaning of the subject to be contextual, 2) Cultivate high-level thinking skills as problem solvers, 3) Facilitate the internalization of learning through experienced practices, 4) Improve students' understanding of sustainable scientific development [16].

The following framework table presents the correlation of elements in RBL-STEM based Science and Mathematics learning to enhance climate change literacy as problem-solving in this research, can be seen in Figure 1. The planning flow regarding the learning stages of the RBL-STEM model is outlined in the Figure 2.

The use of teaching aids made from recycled materials to create water-powered lamps is of very high research urgency because it contributes to more effective solutions in learning about renewable energy. Some of these urgencies include: Enhancing students' understanding of renewable energy, utilizing recycled materials thus reducing waste in the environment, and innovation and technology development. Through this research, solutions can be developed that use recycled materials as water-powered lamp creations to enhance climate change literacy			
Science	Technology	Engineering	Mathematics
Utilizing recycled bottle caps and used ice cream sticks as materials to create a water wheel to reduce waste in the surrounding environment.	Using the Google search engine on Android to find materials that can convert water energy into electrical energy and then into light energy. Using the TikTok app to create and upload videos on how to make a water-powered lamp.	Designing sketches for a water-powered lamp using a water wheel made from recycled bottle caps, a generator, and an LED light.	Determining the number of recycled bottle caps and the length of used ice cream sticks as materials for making the water wheel. Calculating the cost of creating the water-powered lamp.

Figure 1 Problem and Problem Analysis of RBL-STEM

3.2. Purpose and Objectives of Student Learning

The learning objective is to impart knowledge to students about the functioning of water wheels by applying renewable energy material. This stage is an initial step in planning the implementation of science learning in creating water-powered lamps through RBL-STEM learning.

The learning objectives to be achieved are:

a. Through the activity of watching water wheel videos, students can identify the structure of objects in the form of water wheels according to the learning theme "Renewable Energy".
b. Through the activity of watching water wheel videos, students can identify the characteristics of objects that can be used to generate renewable energy in the creation of water-powered lamps according to the learning theme "Renewable Energy".
c. Through discussion activities, students can determine the number of used bottle caps, the size of used ice cream sticks required to create water-powered lamps until successfully converting water energy into electrical energy and then into light energy.
d. Through information exploration, students can create a work according to the learning theme "Renewable Energy".

The expected learning outcome is that students can design and create simple water-powered lamps by utilizing used bottle caps and ice cream sticks available in their home environment. This learning outcome demonstrates the development of students' climate change literacy skills in solving problems related to renewable energy.

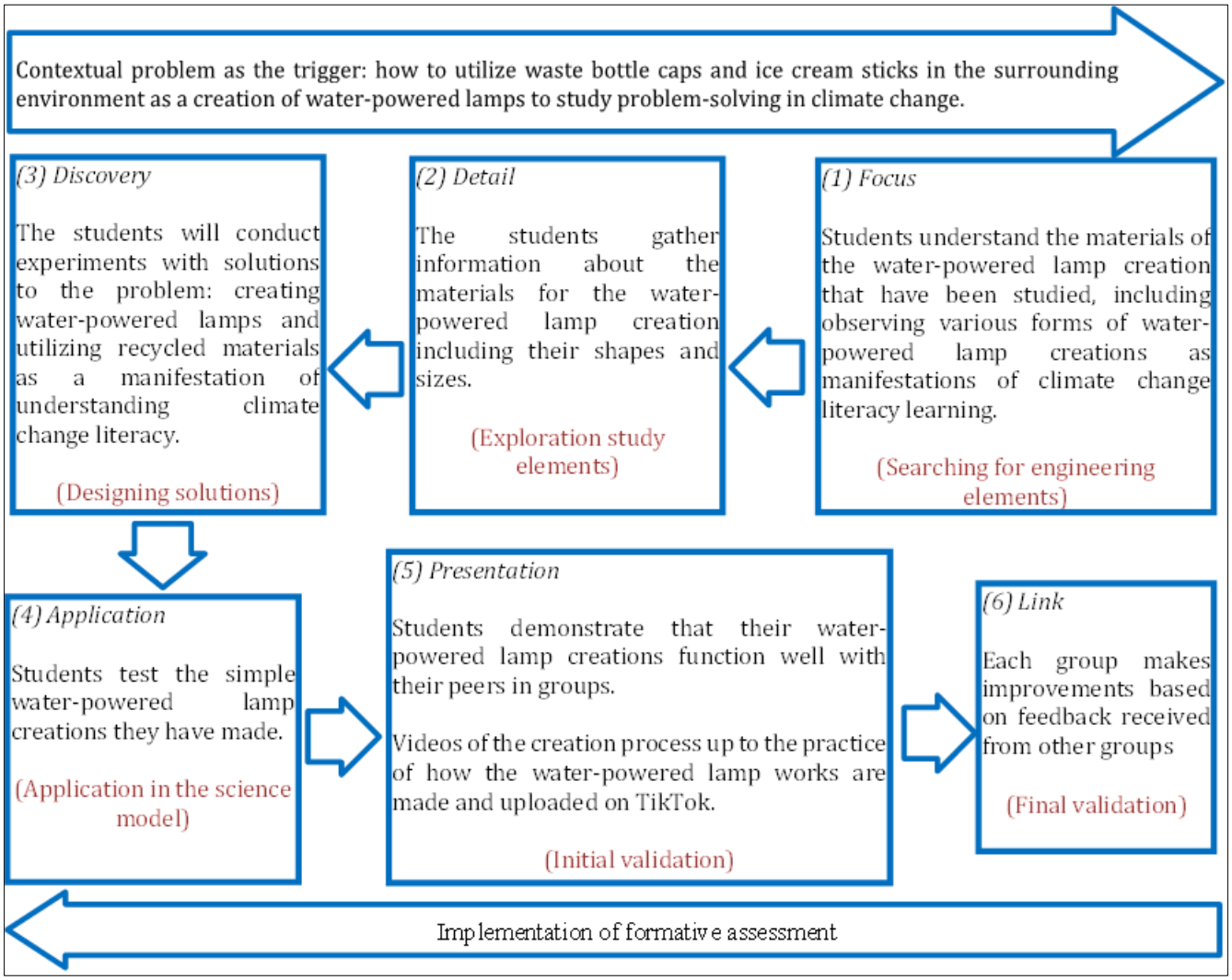

Figure 2 Science Learning Framework with Water-Powered Lamp Creation in RBL-STEM Learning

The purpose of science learning in the creation of water-powered lamps with RBL-STEM is to develop knowledge and skills in several disciplines such as science, technology, engineering, and mathematics, as follows:

a. Science, where students are expected to understand renewable energy that can replace non-renewable energy, as well as environmentally friendly materials and tools to convert water energy into electrical energy and then into light energy. Students are also expected to solve present or future climate change issues.
b. Technology, where students are expected to utilize technological developments, such as TikTok to gather information, edit videos, create reports, and campaign by sharing their video creations with others.
   Literature sources:
   Renewable energy:
   https://www.youtube.com/watch?v=Qu7yVecfJEM
   Creativity in using recycled materials:
   https://www.youtube.com/watch?v=TB8k6rJDoEY
   Building a house from ice cream sticks:
   https://www.youtube.com/watch?v=WQbTdSlaPSY
   Using the internet for design and techniques in creating water-powered lamps.
   Literature sources:
   https://www.youtube.com/watch?v=1Rub_0oDq9Q
   https://www.youtube.com/watch?v=botlt9_Lzxo
   https://www.youtube.com/watch?v=RVTq044WNxA
c. Engineering, where students are expected to understand the techniques for making simple water-powered lamps by applying the working system of a hydroelectric power plant and its use as an action to solve problems in addressing climate change, as well as utilizing recycled materials used in the creation of water-powered lamps.
d. Mathematics, where students are expected to accurately calculate the materials and costs needed to create simple water-powered lamps.

3.3. Elements of Developing Science Learning with an RBL-STEM Approach

Science Problem Elements

The creation of a water-powered lamp is a simple miniature that adapts the working mechanism of a hydroelectric power plant to generate electricity. This creation has a system that receives water flow and moves it through a turbine equipped with a generator to convert the kinetic energy in the water into electrical energy that can power a lamp. The creation of this lamp also uses recycled materials, making it clean, inexpensive, and environmentally friendly.

Figure 3 Used ice cream sticks and recycled bottle caps

Technology Problem Elements

Students utilize Google search engine technology to find information about creating water-powered lamps.

Figure 4 Students learning by using devices to search for information.

Some students upload the process and results of their water-powered lamp creations on TikTok: https://vt.tiktok.com/ZSN91PCrN/

Engineering Problem Elements

The design sketch for the water-powered lamp involves a water wheel made from recycled bottle caps, a generator, and an LED lamp. The steps are as follows:

Students listen to the problem presented.

- Students engage in literacy activities to determine the type of water-powered lamp they will create and communicate this to the teacher.
- Students make a simple design with an estimate of the materials needed.
- Students prepare the tools and materials.
- Students estimate the size of the ice cream sticks needed to make the water wheel.
- Students cut the ice cream sticks as needed, creating parts (water wheel, generator, housing, and lamp).
- Students refine the creation of the water-powered lamp.

a. Mathematics Problem Elements

Students calculate the number of bottle caps and ice cream sticks needed to make the water wheel and the associated costs.

3.4. Framework for Science Learning with an RBL-STEM Approach in the Utilization of Simple Water-Powered Lamp Creations

The RBL-STEM approach does not have a standard syntax that must be followed like other learning models. In this research, the steps of the RBL-STEM approach in learning refer to: https://youtu.be/Y9A9phAcDGE?si=6Vy5sJj3Qs2hTVuz (accessed on Tuesday, December 12, 2023), which can be described as follows:

The focus is on selecting important questions or problems that need to be solved by concentrating on RBL-STEM. The learning activities in the first stage are detailed in the following Table 1:

Table 1 Focus Learning Activity Stages

Stage 1	**Learning activities**
focus	Students watch a video about a simple water-powered lamp creation (Science)
	Students pay attention to the problem presented by the teacher.
	Students read and research each problem one by one.
	Students can design general steps to solve the presented problems through brainstorming activities.

Detail involves identifying elements that contribute to the problem or important question. Students need to gather information to answer the questions at this stage.

Table 2 Detailed Learning Activity Stages

Stage 2	**Learning activities**
DETAIL	The students are divided into five groups
	Students observe the miniature of the simple water-powered lamp creation and the images provided by the teacher. Students are also allowed to search for information on the internet.
	The teacher distributes LKPD 1 about guidelines for using energy through the creation of a simple water-powered lamp (Technology).
	Students write down their observations on LKPD 1.

Stage 2	Learning activities
	The teacher circulates, observing the work of each group and providing guidance and feedback needed regarding the completeness and clarity of each group's information collection.

a. Discovery means that students are searching for solutions that will be provided and existing solutions that have not yet resolved the problem.

Table 3 Discovery Learning Activities

Stage 3.	Learning activities
DISCOVERY	Students prepare activities to create a water-powered lamp.

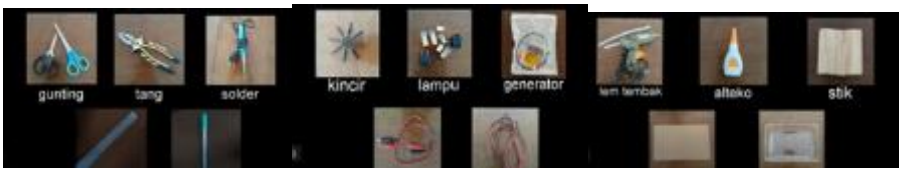

Figure 5 Preparation of tools and materials

b. Application means that students begin to create works that solve problems by utilizing skills, processes, and knowledge they have previously learned and applying them in practice.

Table 4 Learning Activities for the Application Stage

Stage 4	Learning activities
APPLICATION	Students collaborate in groups to create a simple water-powered lamp that reflects the students' creative nuances according to the specified design and FGD in desigh engireeng (Engineering).
	Students determine the size and amount of materials needed for the creation of a simple water-powered lamp (Mathematics).
	Students test the simple water-powered lamp they have created.

Figure 6 Students creating a water-powered lamp

c. Presentation means that students communicate the solutions or works they have created. Presentation also serves as a means for students to express themselves based on their perceptions of the observed problems.

Table 5 Presentation Stage Learning Activities

Stage 5	Learning activities
PRESENTATIoN	Students demonstrate that their water-powered lamp creations function well with their peers in groups.
	Students collaborate in groups to communicate the products they have created.

Figure 7 Presentation of group work results

d. Link means that students have the opportunity to reflect on the feedback given, revise their work as needed, and produce even better solutions.

Table 6 Linking Stage Learning Activities

Stage 6	Learning activities
LINK	The products of problem-solving that have been presented are then displayed on the table provided for each group.
	Each group makes improvements based on feedback received from other groups.
	Students pay attention to the reinforcement provided by the teacher regarding the learning material.
	With the help of the teacher, students write down the conclusions of the learning material.

3.4.1. Framework for the Student Creativity Thinking Ability Assessment Instrument

The instrument used to measure students' thinking abilities is the student creativity observation sheet. This sheet includes indicators of the creative aspects to be observed. The three aspects observed are fluency, flexibility, and originality.

Table 7 Framework for the Creative Thinking Ability Assessment Instrument

Indicator	Sub-Indicator	Test Material
Fluency	Problem-solving with various interpretations, a problem-solving method, or its solutions. Students can provide appropriate solutions to the problem.	Problem: How can water energy be used as a replacement for fossil energy in generating electricity?

Indicator	Sub-Indicator	Test Material
Flexibility	Solving a problem in one way and then using another method Discussing several problem-solving methods	Students will provide varied answers from different perspectives related to the problem
Originality	Researching various problem-solving methods or answers and then creating another different answer	Students can provide solutions based on their own thinking to the problem of utilizing water energy by designing their ideas

3.4.2. Follow-Up Development of Learning Materials

The follow-up development of learning materials in this research refers to the 4D development model, which consists of four stages: define, design, develop, and disseminate. The 4D model was chosen because its stages are sequential, clear, and suitable for the development needs of science learning materials with an RBL-STEM approach. The stages are as follows:

- Definition Stage

In this stage, there are five defining steps: problem analysis, concept analysis, task analysis, and formulation of learning activity objectives. This stage is the initial step in creating a science learning plan within the RBL-STEM framework.

- Design Stage
  - This stage involves designing the components of the learning materials being developed, encompassing several steps:
  - Preparing assessment criteria to ensure tests remain relevant to the assigned tasks.
  - Selecting the model used in learning, which is learning within the framework of the science subject on renewable energy using the RBL-STEM approach.
  - Choosing the format by adjusting the learning model to a suitable format for easy use.
  - Initial design consisting of teaching modules, LKPD (Student Worksheets), and climate change literacy tests.
- Development Stage

In this stage, the produced tools will undergo validation tests from various relevant experts. Subsequently, a trial will be conducted with 25 fourth-grade students at SDN Tenggilis Mejoyo I Surabaya.

- Dissemination Stage

Once the product is declared valid and suitable for use, the learning materials can be implemented in lessons with similar topics in other classes, by other teachers, or even in other schools. Dissemination can be done through social media, training sessions, or learning communities.

4. Discussion

The development of RBL-STEM learning materials to enhance students' climate change literacy skills is beneficial for everyday learning. The urgency of solving climate change issues is integrated into the literacy concept that encourages students to study real-world problems. Climate change literacy can serve as a means to cultivate students' awareness and understanding of current environmental conditions through the use of more environmentally friendly and sustainable renewable energy. Students can directly understand the concept of climate change through meaningful learning by linking learning materials to real climate change issues.

Students' climate change literacy skills in this development are demonstrated through the preparation of pretest and posttest sheets containing climate change literacy indicators. These indicators serve as a reference for measuring students' abilities. In this context, the questions used are subjective to foster students' critical thinking and problem-solving skills.

The RBL-STEM approach in these learning materials is also reflected in the RBL-STEM learning stages outlined in the previous Figure 1. The integration of Science, Technology, Engineering, and Mathematics is evident in research-oriented learning, specifically the experiment of creating simple water-powered lamps. The developed learning materials are also complete in components, including teaching modules, LKPD (Student Worksheets), learning media, and Student

Outcome Tests (THPD). The teaching modules are tailored to the learning objectives and outcomes aligned with the "Kurikulum Merdeka" for the fourth-grade science subject on renewable energy [2].

The development of learning materials integrated with the renewable energy topic is expected to comprehensively improve students' climate change literacy skills. Consequently, students can apply their knowledge and thinking skills in real-life situations to address current and future climate change issues.

5. Conclusion

The developmental research was conducted by applying the 4D model through the stages of defining, designing, developing, and disseminating. This research produced RBL-STEM model learning materials aimed at improving students' climate change literacy skills. The RBL-STEM learning model framework was demonstrated in the creation of simple water-powered lamps, incorporating renewable energy material in the fourth-grade science curriculum. The creation using recycled materials prompted an increase in climate change literacy as a simple problem-solving action regarding renewable energy. Additionally, students' climate change literacy skills were measured using a climate change literacy test, encouraging them to enhance their literacy and problem-solving abilities concerning their surrounding environment. Thus, students gain awareness and understanding to preserve the environment for a better future on Earth.

Compliance with ethical standards

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Disclosure of conflict of interest

I would like to disclose that I am the author responsible for this research, collaborating with other authors as a team. Although I will strive to remain objective throughout the article preparation process, I feel it is important to disclose my relationship with the other authors.

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