

# How to Develop Teaching Material to Promote Student's Scientific Literacy Through Blended Learning at Junior High School?

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## Abstract

The purpose of this study was to develop teaching material to promote student's scientific literacy through blended teaching material on junior high school. This teaching material was developed using the ADDIE design. Having analysed and designed steps, the online teaching material draft was then validated by five experts and twenty science teachers. Furthermore, the teaching material about the earth's atmosphere implemented to 38 junior high school students. Data collection uses scientific literacy tests, observation, and questionnaires. The analysis of data was carried out descriptive quantitative. The results showed that the teaching material has been valid based on the result of five experts and twenty teachers assessing. The teaching material on earth's atmosphere was able to promote students' scientific literacy in terms of students to identify atmospheric issues in life, make conclusions based on evidence, and understand of the concepts. Students also expressed satisfaction with the content and presentation of teaching material.

**Keywords:** scientific literacy, teaching material, earth' atmosphere, blended learning

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## 1. Introduction

### 1.1 Background of the study

The essence of natural science is science as knowledge, as process, and as attitude. Therefore, these subjects not only prioritize the knowledge but also give attention to the processes and attitudes of science. This is intended so that junior high students have good scientific literacy. According to Schroeder et al. (2009), scientific literacy has three main elements; the first element relates to good science process skills, so that they can use them in estimating, manipulating, observing, and it also relates to skills that become the facts and concepts of basic scientific. The second element is the understanding of the nature of science (NOS). The essential nature of scientific literacy will influence student decisions on personal and community problems (Lederman et al. 2013). The last element in the scientific literacy is the understanding of the role of science and technology in social and cultural contexts. A person who has scientific literacy must have the competence to explain natural phenomena, design and evaluate investigations, and interpret data and evidence scientifically (OECD, 2016a).

One of the parameters of the quality of a nation's education is the results of the assessment of the Program for International Student Assessment (PISA). The result of PISA assessment in the last two periods shows that the achievement of scientific literacy of Indonesian students is still low, which occupies the position of 62 out of 70 participants with an average achievement of scientific literacy of 403 (OECD, 2016b) and occupies the rank of 70 out of 78 participants with scientific literacy achievements of 396 in 2018 (OECD, 2019). The scientific literacy achievement is still below the average of 493 in 2015 (OECD, 2016b) and 489 in 2018 (OECD, 2019). The causes of students' low scientific literacy are influenced by teacher's scientific literacy (Rubini et al., 2016). According to Kartal et al. (2018), the students and teachers' scientific literacy is still low because their understanding of NOS is also low. The results of the NOS study mention that some science teachers have misconceptions about NOS (Akerson et al. 2009 and Dogan & Abd-El-Khalick 2008). Therefore someone needs

to have an adequate understanding of NOS in order to understand about scientific content and have the ability to connect scientific concepts to obtain scientific knowledge in a coherent manner (Michel & Newmann, 2017; Kartal et al., 2018; and Nelson et al., 2019).

However, the efforts to improve scientific literacy have been carried out through learning activities and teaching materials used by teachers (Rusilowati, 2016). The term of teaching materials is defined as a set of learning tools which are used to achieve competencies in the form of subject matter, methods, and evaluation (Hendriana et al., 2019). It plays an important role in the learning process since it is used to deliver information. Therefore, to achieve learning objectives maximally, good teaching materials are needed. Chiappetta et al. (1991) states that good science teaching materials are teaching materials that contain components of scientific literacy, science as a core of knowledge, science as way of investigating, science as a way of thinking, science interaction, technology, and society. According to the findings of the research conducted by Ardianto & Pursitasari (2017), the scientific literacy profile of teaching materials is still focused on scientific knowledge, but it contains minimum investigation of the science nature, science as a way of thinking, and the interaction between technological science and society. Thus, the scientific aspect literacy is still not comparable with teaching materials and the exceptional limitations of teaching materials make it difficult for students to understand science individually.

The most important thing is that with the latest technological and information developments, the students are required to have information literacy skills, media and technology. Therefore, the teaching materials that contain scientific literacy in a proportional manner and are easily accessible anywhere such as electronic teaching materials are needed. This teaching material can be used in online or face-to-face learning or used in blended learning. Blended learning combines various learning activities such as face-to-face classrooms, live e-learning, and independent learning (Singh, 2003). Blended learning can improve the effectiveness of learning anatomy (Pereira et al., 2007), strengthen teaching competence (Singer & Stoicescu, 2011), science education (Stockwell et al., 2015), and logic programming (Van Niekerk & Webb, 2016).

Based on observations, some teaching materials about earth's atmosphere and dynamics are still limited to electronic teaching materials, and these teaching materials do not refer to scientific literacy. Therefore, students are required to have adequate visualization skills because conceptual visualization is needed to help students understand it. Referring to the problem, the development of online teaching materials based on scientific literacy is very much needed. Studies on the use of learning in online learning environments have increased (Tsai & Wu, 2017). The results of these studies indicate that online learning can improve learning efficiency and it also provides creative thinking and meaningful activities in the classroom, and it is also a suitable practice skills to enhance students' critical thinking (Moore et al., 2011; Gündüz et al., 2016; Li, 2017; Al-Zahrani et al. 2015; Şendağ & Odabaşı, 2009). In addition, it was revealed that the dynamic nature of the online environment affects student participation in learning.

### *1.2 Research Question*

Based on the background of the study, the research questions are:

- a. How are the characteristics of earth's atmosphere teaching materials to promote students' scientific literacy?
- b. How is the validity of earth's atmosphere teaching materials based on the results of expert and teacher assessments?
- c. How can earth's atmosphere teaching materials promote student's scientific literacy through blended learning?

### *1.3 Objective of the Study*

The objective of this research was to develop teaching material to promote student's scientific literacy through blended teaching material on junior high school.

## **2. Methods**

### *2.1 Subject of Research*

This research was conducted at a Junior High School in West Java. This research involved 5 experts, 20 science teachers, and 38 junior high school students consisted of 10 boys and 28 girls.

### *2.2 The develop of teaching material*

#### **Research Design**

The Development stage of Online Teaching Materials using ADDIE models consists of:

#### **Analysis**

This step was conducted to obtain the information by having library and field studies in science lesson. This step consisted of five stages to find existing problems and the appropriate solution. The stages carried out at the analysis steps are among others:

- a. Analysis of performance gaps includes issues that have an impact on the achievement of learning objectives.

By measuring existing performance and determining the performance to be achieved, the problems that cause the achievement of the learning objectives are not achieved then can be identified. The performance gap analysis process is carried out through field surveys and literature studies. To obtain data from field studies, researchers used a needs analysis questionnaire that was distributed to students and teachers.

The survey contains questions about the difficulties faced by teachers and students in answering questions about scientific literacy and science material that are difficult for students and teachers to find. Data on the study of literature on gaps in scientific literacy performance is obtained by conducting literature studies on scientific literacy, teaching materials based on scientific literacy, steps to develop scientific literacy-based teaching materials, and evaluating the development of science-literacy-based teaching materials. This will be a reference for how the web teaching material is further developed.

Based on the result of literature review and field surveys which was distributed to 18 science teachers and 84 students of Junior High School in one of district in Indonesia, the data was shown in Table 1.

Table 1. Literature Review and Field Survey Result

No	Analysis	Results/Findings
1.	Performance Gaps	a. Teaching materials do not yet contain balanced scientific literacy, especially in the aspects of natural science inquiry; science as a way of thinking and interacting with science, technology and society (Ardianto & Pursitasari, 2017). b. There are about 28% of teachers who have never used online teaching materials. c. There are as many as 40% of students who have never used online teaching materials. d. There are 83% of teachers who find some difficulties to teach material about the earth's atmosphere and subject dynamics due to difficulties in imagining the logic or process that occurs. There are as many as 11% of the total sample of teachers who do not practice and the number of teachers who feel that science lessons are not interesting is 6%. e. There are as many as 60% of the number of students who become research samples who have difficulty in learning material about the atmosphere and dynamics of the Earth. As many as 70% of students experience difficulties because it is difficult to imagine the logic or the process, as many as 10% of students answer because they lack training, and as many as 9% of students say that the material used is incomplete. The remaining 1% of students finds science unattractive.
3.	Junior High Students	a. The seventh grades students of SMP Cianjur are in the age range of 11-13 years and they are in a transition phase from concrete operations to formal operations. b. There are 92% of the students who are interested in online teaching materials. c. There are 92% of the total number of students who become research samples who agree to develop online teaching materials based on scientific literacy for material about the material layers of the Earth's atmosphere and dynamics.
4.	Human Resources	a. There are as many as 72% of the teachers have used online teaching materials. b. 100% of the teachers agree to develop online learning materials based on scientific literacy for the material layers of the Earth's atmosphere and dynamics. c. About 73% of the students have gadgets to access the internet. d. There are 60% of the students have used online teaching materials.

Table 1 shown that the teaching materials available do not contain aspects of scientific literacy, and the teachers also still have difficulty in carrying out learning about the material of the Earth's atmosphere. However, there are some students who have gadgets that can be used for learning. Therefore, the development of online teaching materials in the material of the earth's atmosphere which contains aspects of scientific literacy is very possible. Development of teaching materials also refers to the national curriculum and the category of scientific literacy.

b. Curriculum analysis

At this stage, the process carried out is the analysis of national curriculum content standards. This step aims to determine the boundaries of the material both in terms of breadth and depth of the material layer of the earth's atmosphere and also regarding the dynamic topic based on core competencies and basic competencies in the national science curriculum for seventh grade.

**Design**

The design phase aims to verify the expected goals for conformity with the developed product specifications. Furthermore, at the end of this stage, the researcher will get the functional specifications of online teaching materials. The steps carried out in this stage are:

- a. Determine the learning objective and content are needed to develop teaching materials that are used to improve students' scientific literacy.

The analysis of learning objectives that refers to basic competencies in the national curriculum and scientific literacy competencies from the 2015 PISA framework produced fourteen learning objectives (Table 2). Table 2 shown the relationship between learning objectives and scientific literacy competencies, namely interpreting data and evidence scientifically (no. 3-5-6-8), explaining scientific phenomena (no. 1-2-4-7-9-10), evaluating and designing scientific investigations (no. 11-12-13-14).

Table 2. The learning objectives on earth's atmosphere topic

No.	Learning Objectives
1.	Identifying the composition of the earth's atmosphere which is essential for life
2.	Describing the formation and decomposition of ozone
3.	Analyzing changes in the composition of the Earth's atmosphere
4.	Identifying layers of the Earth's atmosphere
5.	Interpreting the phenomenon of differences in atmospheric air pressure
6.	Interpreting the difference in temperature data of the Earth's atmosphere
7.	Identifying weather and climate elements
8.	Interpreting changes in weather and climate elements
9.	Identifying actions to reduce the risk of meteorological natural disasters
10.	Giving an example of the benefits of the earth's atmosphere for living things
11.	Investigating cloud formation
12.	Making weather station tools
13.	Presenting actions to reduce the risk of impacts before a natural disaster
14.	Presenting self-safety actions in the event of a natural disaster

Based on the learning objectives in Table 2, the content that will be included in the teaching material consists of five topics that are: (1) the composition of the atmosphere describes the constituent gases of the atmosphere and the source of gases in the atmosphere; (2) the atmosphere's layers describe troposphere, stratosphere, mesosphere, thermosphere, and exosphere; (3) atmospheric dynamics describe changes in temperature and air pressure of the atmosphere layer and elements of weather and climate; (4) the benefits of the atmosphere for living things describe the protection of space objects, ultraviolet radiation, and extreme temperatures; and (5) meteorological natural disasters describe floods, droughts, tornados and global warming.

b. Determine the design of teaching materials based on scientific literacy categories;

This stage is done to make the icons presented by referring to the four categories of scientific literacy, namely: science as knowledge body, science as a way of investigation, science as a way of thinking, and interaction between science, technology and society.

#### **Develop**

The development phase is carried out to determine the validity of online teaching materials and research instruments produced at the design stage. The validation of teaching material was carried out by two experts in science education and two senior science teachers. Furthermore, the teaching materials were assessed by 20 science teachers who have more than five years teaching experiences and are professionals (having educator certificates). The data were then analysed by using content validity ratio (CVR) and content validity index (CVI) techniques. The result of CVR and CVI is categorized to determine the eligibility of teaching materials. According to Herdiana et al. (2019), the criteria for eligibility teaching material are highly eligible (83.5%-100%), eligible (64.5%-83%), eligible enough (44.5%-63%), and not eligible (25%-44%).

The validation process scientific literacy test was carried out by two expert and then empirically by 27 students. The scientific literacy test (SCT) consisted of 15 multiple choice questions, 5 essay questions, and 15 attitude tests with a reliability coefficient of 0.729; 0.793; and 0.751 respectively

#### **Implementation**

Teaching materials were implemented to 28 students of seventh grades of junior high school. It was conducted using one group pre-test and post-test design (Fraenkel & Wallen, 2009). The implementation of the teaching material which was carried out in four sessions. The first lesson was discussing the composition of the earth's atmosphere and the vertical structure of the atmosphere. The second and third lessons were discussed atmospheric dynamics and meteorological disaster and its mitigation. The fourth lesson discussed meteorological disasters and the benefits of the atmosphere. The second and fourth meetings are held online. Learning resources used are earth atmosphere teaching materials. Students read its before participating in science learning. During the study observations were made by two observers.

#### **Evaluation**

Evaluation process was carried out on the learning process, scientific literacy of students, and the response of students after learning by using online teaching materials.

### **2.3 Research instrument**

The instruments of this study consisted of scientific literacy tests in the form of multiple choice and essay, expert

validation sheets for content experts, observation sheets, and students' response questionnaires. The scientific literacy test instrument uses the 2015 PISA framework. The scientific literacy aspects used are:

- a. Scientific competencies, including explain phenomena scientifically; evaluate and design scientific inquiry; and interpret data and evidence scientifically;
- b. Scientific knowledges, including content knowledge, procedural knowledge, and epistemic knowledge
- c. Attitudes, including interest in science, evaluate inquiry, and environmental awareness

#### 2.4 Data analysis techniques

Data of expert validation and teacher assessment, observation, and questionnaire were analyzed descriptively quantitative and then categorized. The scientific literacy data calculated N-gain then categorized refer to Table 3.

Table 3. N-gain categorization

N-gain	Category
$(N-gain) \geq 0,7$	High
$0,7 > (N-gain) \geq 0,3$	Medium
$(N-gain) < 0,3$	Low

Hake, 1999

### 3. Result and Discussion

#### 3.1 Design of Teaching material

The teaching material features are arranged based on the categories of teaching materials that support scientific literacy namely, science as a body of knowledge, science as a way of investigation, science as a way of thinking and interacting between science, technology and society (Chiappetta et al., 1991). The features developed are; "Why?", "Let's Learn Deeper", "Let's Read", "Did You Know", "Let's Check" and "Reflection" activities. The relationship between features in online teaching materials and scientific literacy categories is shown in Table 4.

Table 4. Relationship features in teaching material with scientific literacy categories

No.	Scientific Literacy Category	Features in teaching material
1.	Science as knowledge body	The features included are "Let's Read", "Let's Check" and "Reflection". These three features present facts, concepts, and principles in atmospheric matter and Earth dynamics. In addition, this feature also presents a model and asks students to remember knowledge or information in the learning process.
2.	Science as a way of investigation	The features contained "Let's Learn Deeper". This feature invites students to answer questions through the use of material, graphs and tables. In addition, this feature also invites students to make calculations and to explain the answer, and also to involve students in experiments and thinking activities.
3.	Science as a way of thinking	The features contained "Why?" This feature shows students historical development of an idea and the empirical nature and objectivity of science. In this feature, students are invited to use assumptions, factual discussion, evidence and they also have to present the solution.
4.	Interaction between science, technology and society.	The features contained in the teaching material is; "Did You Know". This feature illustrates to students how science and technology are used for society and it also shows the negative effects of science and technology for society. In addition, this feature also invites students to discuss some social issues related to science or technology.

Table 4 shows the design of teaching materials that contain concepts and categories of science supplemented with drawings or images. Presentation images in the text can provide students with early mental scaffolding (Eitel et al., 2012). This can also facilitate the construction of further mental models in the text. According to Eitel & Scheiter (2014), the images presented at the beginning or along with the text can facilitate learners' understanding. If the image is placed after the text, then it can reduce understanding, because mental models are built based on image representation (Schnotz & Bannert, 2003). Furthermore, Lindner et al. (2018) says that images added in text and test material can improve the performance of teaching materials. The teaching materials are also designed using colorful images so that the students will be interested. Kotkas et al. (2016) said that students would be interested in using teaching material if the teaching material has interesting, colorful and contextual features.

#### 3.2 Teaching material Validation

The validation of teaching materials by experts was carried out by two content experts. The results of the

validation of the content experts were presented in Table 5.

Table 5. Result of Teaching material Validation by Experts

Aspect	Mean
Content Eligibility	1
Presentation Quality	1
Language Quality	1
Science Literacy	1
<b>Average of content</b>	<b>1 (high eligible)</b>
<i>Usability</i>	1
<i>Functionality</i>	1
<i>Visual Communication</i>	1
<b>Average of media</b>	<b>1 (high eligible)</b>

Table shows the teaching material has a mean of 1 (high eligible). This means that the instructional materials that are designed are appropriate based on the results of expert judgment. In addition to providing an assessment, experts also provide suggestions as listed in Table 6.

Table 6. Suggestion to the teaching material design

No.	Suggestion
1.	Learning indicators are replaced by learning objectives, there is no need to separate knowledge and skills
2.	The reaction of decomposition and formation of ozone is not appropriate
3.	The term of Equinox has not yet entered the glossary
4.	The consistency of text writing
5.	Need a special form in the main menu
6.	Add feedback after students work on the competency

After a revision based on the validators' advice, the teaching material was assessed by 20 science teachers with the criteria of professional teachers. The results of teacher assessment and CVI calculations are in Table 7.

Table 7. Result of teacher's assessment to the subject matter

Focus of Assessment	Component	CVI Value
Content	Content Eligibility	0.98
	Presentation Quality	0.94
	Language Quality	0.96
	Scientific Literacy	0.93
<b>Average of content</b>		<b>0.95 (high eligible)</b>
Media	Usability	0.95
	Functionality	0.95
	Visual Communication	0.88
<b>Average of media</b>		<b>0.93 (high eligible)</b>

Table 7 shows the average CVI scores for the subject matter is 0.95 and media is 0.93 with criteria high qualifications. After the revision, online teaching materials are simulated to small group students. The group consisted of 10 students of eight and nine grades to obtain students' satisfaction before using the media in teaching and learning process. The result of student satisfaction is presented in Figure 1.

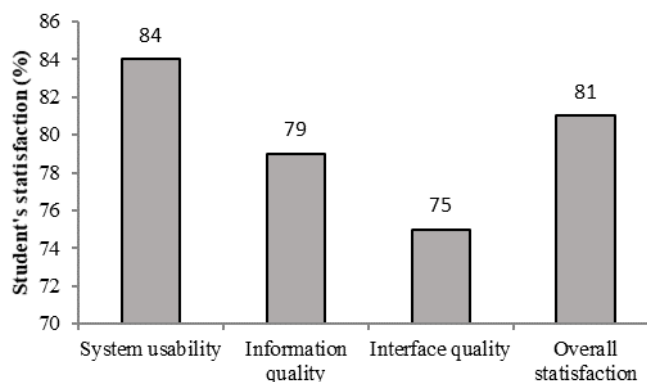


Figure 1. Responds of small group towards teaching material

Figure 1 shows the average value of student satisfaction with online teaching materials 81 with the highest satisfaction on system usability and lowest interface quality. Students are satisfied with the use of the web because it is simple, effective, comfortable, and it can improve learning activities. This is in line with the

statement of Hiltz & Turoff (2005) and Rekkedal (2003) that online learning is easily accessible, flexible, and supports a variety of interactions.

### 3.3. Implementation

Teaching materials that have been valid are implemented in the learning of the earth's atmosphere. This implementation was carried out because based on the results of the students' understanding of the teaching material developed, it had an average value of 51%, so that it was included in the "instructional" category. This means that the atmosphere's teaching materials can be used by students with the help of a teacher or facilitator through the learning process.

The learning of the earth's atmosphere begins with the teacher asking the following questions: "Have you ever thought about why we live on planet Earth, not on Mars? What exactly does the Earth's atmosphere have so we can live easily?" This activity describes science a way of thinking. In addition, students also watched a video about the animation of aerosol distribution in the atmosphere. Next, students fill in the table of observations about interesting things contained in the video such as aerosol type, storm type, aerosol distribution visualization function, and others. This activity states science as a body. Science facilitates students to build knowledge and enhance understanding of the nature of science. According to Bakirci et al. (2017), learning based knowledge construction can improve students' understanding of science.

Various activities are also carried out by students such as practicum for cloud formation, making weather instruments from materials in daily life such as straws, paper, balloons, glue, and others. All stages of practicum are contained in teaching material. During the investigation, students explain the phenomena that occur, interpret data, and solve problems (Serpell, 2011). Investigation activities can also improve scientific literacy and observations skills (Gormally et al., 2012; Brickman et al., 2009), and reading habits which are one of the elements to improve student's scientific literacy (Putra et al., 2016). Students also learn the links between science, technology, and society. Teaching material contain the composition of the planet's atmosphere even though far away from earth, describes the use of technology related to the atmosphere such as observatories, radio sounder, or other weather measuring devices. The implementation of blended learning using teaching materials was observed by two observers. The result of observations was presented in the Table 8.

Table 8. The results of observations of blended learning with teaching materials.

Learning activity	Percentage of implementation (%)
Observation	87.5
Asking question	81.3
Experiment	81.3
Analysis	81.3
Communicate	81.3
Reflection	75.0
Conclusion	75.0
Do feedback	87.5
Assessment	87.5
Mean	81.97

Table 8 shows the percentage of the feasibility of learning the atmosphere of the earth using teaching materials and scientific approaches have an average of 81.97% (good category). The combination of teaching materials and scientific approaches facilitates students to understand knowledge and the science process and have a better attitude in science. This is in line with Fallon (2019), Lindner et al. (2018), and Rubini et al. (2018) that said the existence of teaching material that combines scientific approach can facilitate students to conduct reasoning and scientific processes

### 3.4 Student's scientific literacy

The effectiveness of teaching materials is determined through the test of the average difference between the pretest and posttest of competencies, knowledge, and attitudes with determination N-gain scientific literacy. The N-gain achievements from every aspect of scientific literacy are shown in Table 7.

Table 7. Achievements of N-gain for every aspect of scientific literacy

No.	Aspect	Indicator	% N-Gain
1.	Competencies	Explain the scientific phenomenon	83
		Evaluate and design scientific investigation	79
		Interpret scientific data and evidence	50
		<b>Average of competencies</b>	<b>71</b>
2.	Knowledge	Content knowledge	69
		Procedural knowledge	66
		Epistemic knowledge	57
		<b>Average of knowledge</b>	<b>64</b>
3.	Attitudes	Interest in science	43
		Evaluate inquiry for inquiry	20
		Environmental awareness	80
		<b>Average of attitudes</b>	<b>48</b>

Based on Table 7, it was found that N-gain of interpreting data and evidence scientifically is in the medium category. This is related to the N-gain value of students' knowledge and attitudes that are in the medium category as well. The ability of one's interpretation relates to the understanding ability. Interpretation is the process of interpreting things through deep thought. According to Ma (2013), interpretation requires reasoning to activate relevant information in long-term memory. Since the students' ability in constructing concepts, cannot be done spontaneously, the teachers can accustom students to observe, record and analyze data in online practice-based activities; therefore, the students will have the ability to interpret data and scientific evidence in (Gündüz et al., 2016). Therefore this teaching material is one of the supports to get students accustomed to practicing the ability to interpret data and evidence scientifically. Achievement of scientific literacy on indicators explaining scientific phenomena is illustrated by the ability of students to recognize, provide and evaluate explanations for various natural and technological phenomena. This ability is demonstrated by students in a form of remembering and applying appropriate scientific knowledge, identifying the use and producing clear models, representing and making and justifying predictions (OECD, 2016a).

The mastery of scientific literacy is influenced by several factors including materials used by teachers in developing learning concepts. Teaching materials that are able to improve students' curiosity related to learning topics will be able to encourage students' enthusiasm to solve the problems. It is presented by the teacher who are believed to be able to build science process skills that are part of scientific literacy competencies aspect. Of course the teaching material developed is in accordance with the rules of developing teaching material, namely teaching material that contains steps of the scientific method in building the concept of knowledge in accordance with the context in everyday life.

## Conclusion

The process of learning teaching development is based on the curriculum, the students characteristics, resources and supporting facilities. Characteristics of teaching materials contain a component of scientific literacy can be made with various activities or features that support the components of scientific literacy teaching materials, namely science as of the body knowledge, science as a way of investigating, science as a way of thinking, interaction of science, technology, and society. The teaching materials developed have a very good category and quite effective to promote students' scientific literacy.

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