



The Development of Biodiversity Teaching Materials Based on Socio Scientific Issues to Improve Students' Science Literacy

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Article Info

Article History :

Received
February 2022
Accepted
April 2022
Published
August 2022

Keywords:

Biodiversity, Scientific
Literacy, Socio Scientific,
Teaching Materials

Abstract

This study aims to test the feasibility and effectiveness of based biodiversity teaching materials Socio Scientific Issue (SSI) in improving students' scientific literacy. This research is a Research and Development (R&D) that use the ADDIE model by applying a one group pretest-posttest design. The research subjects to test the teaching materials developed were two expert lecturers consisting of Biology material experts, media experts, practitioners and 125 students of grade X MIPA in Kudus. The research instruments are expert validation questionnaire, readability questionnaires of teaching materials and scientific literacy test questions. The analysis of the expert validation questionnaire data showed the average score on the feasibility aspects that were considered very valid. The readability questionnaire analysis describes the teaching materials as having very good readability, which meant that the teaching materials were easy to understand and read by students. The results of the N-gain analysis of scientific literacy for each aspect of scientific literacy are in the moderate category. The aspect of science as a body of knowledge is 0.49, science as a way of investigation is 0.52, science as a way of thinking is 0.50 and the interaction of science, technology and society is 0.56. Based on the results of the analysis of biodiversity teaching materials based on the Socio Scientific Issue, it is suitable to be used in learning and is effective in improving students' scientific literacy skills.

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p-ISSN 2252-6412

e-ISSN 2502-4523

INTRODUCTION

Indonesia is an archipelagic country with a tropical climate with a high level of wealth the world's highest natural and biological diversity. Indonesia's biodiversity occupies second in the world after Brazil (Artanti, 2019). Indonesia's very strategic geographical position is one of the factors causing the high biodiversity (Retnowati & Arifiani, 2019). Biodiversity refers to the variety of biological resources which can be seen from the level of ecosystem, species, and genetics (Prasetyo, 2017). The potential for diversity of flora and fauna in Indonesia is very high. One example of the variety of flora and fauna in the Muria forest area, which is located in Kudus Regency, Central Java. Communities around the forest use forest products to meet basic needs, such as food, energy and medicine. By the local community, the Muria forest area was also developed into a tourist attraction to meet the economic needs of the local community.

Indirectly, biodiversity affects various aspects of people's lives (Rintelen et al., 2017). Biodiversity and its ecosystems are part of the most important of natural resources whose presence cannot be replaced (Nugroho, 2019). In fact, various declines in ecosystem conditions have occurred, both caused by activities humans and changes in natural conditions (Mahipal, 2018). Overexploitation, illegal hunting, forest conversion, habitat loss and the introduction of invasive species threaten biodiversity. Damage to ecosystems and the environment is a form of human behavior who don't care about the environment. This indifference and indifference can become threat of loss of biodiversity in nature. Humans assume that the use of nature is commonplace, so humans can take advantage of nature without thinking about the impact.

This condition shows that scientific literacy is not inherent in a person so that critical thinking and reasoning skills are still weak, especially in dealing with problems in life (Rubini, 2018). Scientific literacy skills are the ability to explain phenomena, interpret data and evidence and evaluate and plan scientific investigation in a scientific way (Kalkan & Altun, 2020). This is where the role of students as the younger generation is needed to be able to solve problems that occur in society.

Scientific literacy is very important for students to master as the younger generation,

because scientific literacy is the main goal of science learning today (Arizen & Suhartini, 2020). Science education prepare students to become science-literate citizens who can take decisions and participate in providing solutions to social problems in people's lives (Leung, 2020). Nofiana & Julianto (2017) explained that one of the keys to success facing the challenges of the 21st century is to master scientific literacy, because individuals who are scientifically literate can use their scientific information to solve problems in life and produce useful scientific product.

The importance of scientific literacy for students contrasts with the results of the PISA scientific literacy test. PISA study results shows that the level of scientific literacy of Indonesian students is still low. Measurement of scientific literacy conducted in 2018 Indonesia is in position 74 of the 79 other countries that follow test (OECD, 2019). These results indicate that Indonesian students still have difficulty making the relationship between scientific concepts and phenomena in everyday life (Rohmawati, *et.al.*, 2018). Based on the results of interviews with biology teachers in four high schools in Kudus Regency, it is known that literacy culture has been applied to students, including through habituation and assignments to read and summarize the material to be studied. However, the literacy that has been accustomed is not maximal in its application in biology learning. Teacher stated that he had never given a scientific literacy test to students, so that the ability of students to analyze questions based on scientific literacy was still low.

The results of filling out student questionnaires on teaching materials applied in biology learning, especially the material on biodiversity, shows that 70.6% of the teaching materials used in the form of a limited book package with a textual discussion. Examples of problems and the pictures presented are still generally not from the environment around students, so make students less able to understand the material and implement it in everyday life.

One of the materials in biology learning in high school is biodiversity. Biodiversity material is one material that is closely related to everyday life students, so that many social issues can be raised to be discussed in learning activities. Forest damage, forest conversion, forest fires, overexploitation have become the public spotlight and have emerged as

social scientific issues. Socio Scientific Issues are complex social problems with conceptual, procedural and/or technology associations with science, which will be encountered in everyday life (Sadler, 2016). SSI is an approach that represents an issue or problem in social life that conceptually related to science. In connection with the development of literacy science, SSI is the right context to achieve the expected goals (Pratiwi et al., 2016).

Learning material on biodiversity delivered by lecture method and utilizing which is dominated by the description of the material causes students to be less enthusiastic and less actively involved in learning. So that students are less responsive in solving problems that threaten biodiversity in nature. Based on the description above, the development of-based biodiversity teaching materials socio-scientific issue (SSI) is a learning media innovations developed by researchers, which can be used by teachers to improve students' scientific literacy skills. Hariapsari et al. (2018) which states that scientific literacy skills can be developed using innovative learning approaches such as the socio scientific issue (SSI).

SSI-based teaching as a practical tool where teachers can contextualize science content and processes so as to develop scientific literacy (Owens et al., 2019). Scientific social problems are open social problems and are closely related to science, so that in scientific investigation, scientific social problems can be used to support perceptions and achieve success in accordance with scientific literacy targets (Memis & Cevik, 2017). Scientific literacy skills can be improved by presenting Biology material which is always associated with social issues of science and technology that exist in society (Purwiyantini et al., 2019). Investigation directed through SSI-based teaching materials, involving students in scientific practice, including identify problems, analyze and formulate data and defend arguments (Leung, 2020). This study aims to determine the feasibility of teaching materials and their effectiveness biodiversity teaching materials based on the Socio Scientific Issue to improve scientific literacy of high school students in Kudus.

METHODS

This research is type of research and development (R&D) that utilizes the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model (Suastika & Rahmawati, 2019). The research subjects consisted of one lecturer who was an expert on biological material, one person media expert lecturers, four practitioners (biology teachers) and 125 students of class X MIPA from SMA 1 Kudus, SMA 1 Jekulo, SMA NU Al-Ma'ruf and MA NU Hasyim Asy'ari 3 Kudus. Research instruments used are expert validation questionnaires, readability questionnaires and 20 scientific literacy test questions. Questionnaire assessment of teaching materials by experts and practitioners using the scale described by Sugiyono, (2017), with four categories of answer choices: type 1) not good, 2) not good, 3) good, and 4) very good. The questionnaire sheet for assessing the readability of teaching materials also uses a scale with four answer choices, namely 1) strongly disagree, 2) disagree, 3) agree, and 4) strongly agree. Aspects of scientific literacy that are measured in this study are four dimensions of science which are: stated by Chiappetta (1991), which includes: science as a body of knowledge, science as a way of investigating, science as a way of thinking, and the interaction of science, technology with society (Rohman et al., 2017).

The first stage of research is the analysis stage. The analysis stage is carried out by doing identification of problems that occur in biology learning, ideal conditions expected and determine possible solutions. The analysis stage is carried out through interviews with four biology teachers and filling out questionnaires by students. The second stage is the design stage which consists of planning teaching materials to be developed and designing learning, namely lesson plans, syllabus, test questions. The third stage is the development stage. This stage includes the manufacture and preparation of teaching materials in accordance with a predetermined design. The specific character of the teaching materials, namely applying the five stage model of the SSI-based learning approach suggested by (Marks et.al., 2014). The first stage of the problem approach is packaged in the "What happened to our environment?" column, the second stage of problem clarification is packaged in the "Dig for more

information!" column, the third stage continues the problem issue in the "Try to think again" column, the fourth stage of discussion and evaluation in the "Let's Discuss" column, and the five stages of metareflection are presented in the "Let's ponder" column. The development stage is followed by validation of teaching materials by material experts, media experts and practitioners. The development stage ended with a test of the readability of teaching materials to teachers and 16 students of class XI MIPA.

The fourth stage is the implementation stage of SSI-based biodiversity teaching materials for to

125 students of class X MIPA from four schools in Kudus using the One Group Pretest-Posttest Design (Ary, 2006). At this stage, a scientific literacy test is carried out at the beginning and at the end learning. The fifth stage of the ADDIE model is an evaluation that aims to evaluate the feasibility and effectiveness of the developed teaching materials in improving student scientific literacy. Analysis of expert validation and readability data using descriptive quantitative percentage techniques. The criteria for the validity and readability of teaching materials are in Table 1.

Table 1. Categories of validity and readability of teaching materials

Data	Percentage (%)	Category
Validity	$81.25 < x \leq 100.00$	Very valid
	$62.5 < x \leq 81.25$	Valid
	$43.75 < x \leq 62.50$	Less valid
	$25.00 < x \leq 43.75$	Invalid
Readability	$81.25 < x \leq 100.00$	Very Good
	$62.5 < x \leq 81.25$	Good
	$43.75 < x \leq 62.50$	Less Good
	$25.00 < x \leq 43.75$	Not Good

Data effectiveness of teaching materials obtained from the results of student test scores (Pretest and Posttest). Data analysis to determine the effectiveness of teaching materials using the N-gain test. The N-gain test aims to determine the increase in students' mastery of concepts. The formula used to determine the gain index is:

$$\text{gain index} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Maximum score} - \text{Pretest score}}$$

The results of the analysis N-gain are categorized according to Hake which are presented in Table 2.

Table 2. Criteria for Gain Index

Score	Category
$g > 0.7$	High
$0,3 < g \leq 0.7$	Moderate
$g \leq 0.3$	Low

RESULTS AND DISCUSSION

1. Feasibility of teaching materials

The feasibility of biodiversity teaching materials based on socio-scientific issue obtained from the data validation of experts and practitioners and data readability of teaching materials. Two experts, namely material experts, media experts and practitioners, namely four biology teachers who carry out validation activities for teaching materials by using fill out a validation questionnaire. Table 3 summarizes the results of the validation analysis of SSI-based biodiversity teaching materials by experts and practitioners.

Table 3. The result of the validation of biodiversity teaching materials based on socio scientific issue.

Expert	Rated aspect	Percentage	Category
Material experts and practitioners	Content eligibility	91.25	Very Valid
	Language eligibility	88.93	Very Valid
	Feasibility of socio scientific issue	89.26	Very Valid
Average		89.81	Very Valid
Media expert and practitioners	Teaching material size	96.88	Very Valid
	Cover design	96.88	Very Valid
	Content design	94.47	Very Valid
	Support for content presentation	94.53	Very Valid
	Presentation equipment	92.97	Very Valid
Average		95.15	Very Valid

Based on Table 3, it is known that the average percentage of validity scores by material experts and practitioners on the aspects of content feasibility, linguistic feasibility and the feasibility of presenting material based on socio scientific issues is 89.81% with very valid criteria. These results indicate that the validators of material experts and practitioners assess that the completeness, breadth and depth of the material in the teaching materials developed are in accordance with KI, KD, learning objectives and indicators of expected competency achievement. Material experts and practitioners also assess that the material on biodiversity in teaching materials is presented in communicative language, easy to understand, does not cause multiple interpretations and is in accordance with student development, making it easier for students to understand the teaching materials used. Nurhayati (2019) states that the language used in teaching materials must be in accordance with the ability level of high school students, sentences that are not convoluted, and direct to the information to be conveyed so that it is easy to understand.

Based on the results of the assessment, it is known that the presentation of scientific issues in teaching materials (shown in Figure 1) is feasible to

be applied in learning activities because it has been declared very valid by the validator. This shows that the presentation of the problem issues contained in the column "What is happening to our environment" and the column "Think about it again", as well as discussion questions contained in the column "Dig for more information", the column "Let's discuss it", and the column "Let's reflect", can support intellectual development, communication skills, social attitudes, concern and student participation. Forming the ability to make decisions on social problems related to science and encouraging students to make connections between the knowledge possessed and its application in everyday life. The five activities contained in the column cover all aspects of scientific literacy that are assessed so that students can train and improve their scientific literacy. Wilsa, *et.al.*, (2017) explained that learning the PBL model based on the Socio Scientific issue resulted in more developed students' critical thinking and verbal communication skills, because group discussion activities in learning made learning centered on students, it made students active and encourage students to communicate with their friends or teachers.



Figure 1. a and b Introduction to scientific social issues, c and d Display of discussion questions

Based on Table 3, it is known that media experts and practitioners also state that teaching materials are very valid or feasible applied in learning, with an average percentage score of 95.15%. Media experts and practitioners assess that the size of teaching materials has met ISO standards by using B4 paper size (250 x 353 mm). The cover design of the teaching materials is very interesting because it contains titles, pictures of flora and fauna typical of the city of Kudus, namely leopards, Javanese eagles, monkeys, parioto, mranak trees, and byar bananas. The cover is also equipped with a logo, the identity of the compiler of the teaching materials, and the target users of the teaching materials. All components are cover designed with an attractive, harmonious, and proportional appearance. Media experts and practitioners also assess the design of content, supporting the completeness of the content and the completeness of the presentation of teaching materials as very valid because teaching materials are supported by pictures, illustrations or key sentences that make it

easier for students to understand the material presented. The use of the size and type of font used is correct, the image layout and margins are also proportional. Figure 2 shows the cover and one of the images or photos assessed in the teaching materials meets the very valid criteria.

This is in line with the research of Nurhayati *et.al.*, (2019) which states that the presence of images in teaching materials is not only intended to clarify the material, but also so that students feel happy and easy when studying teaching materials. Susanti, *et.al.*, (2015) explained that when the language used is less communicative, it can be assisted by the use of appropriate illustrations, because with the illustrations, students will be more interested and able to imagine and understand the material presented.



Figure 2. (a) Cover display of teaching materials, (b) Display of sample images/photos in teaching materials.

Assessment of SSI-based teaching materials from experts and practitioners shows that the developed teaching materials are very suitable for use in the biological learning process of biodiversity materials. These results follow previous research on the feasibility test of teaching materials based on the socio scientific issue approach which was declared very valid to be used for the learning process (Hariapsari, *et al.*, 2018).

Experts also provide suggestions as material for improving the module before it is applied in learning. Material experts provide suggestions for adding pictures of the flora and fauna typical of Kudus and the problems that exist in Kudus. Another suggestion from material experts is to add assignments for students as an assessment of the psychomotor domain and in addition to the local name, the picture is equipped with a scientific name. Practitioners, namely biology teachers, provide suggestions for providing complete explanations on the sub-materials of in-situ and ex-situ conservation efforts, to make it easier for students to understand the material in teaching materials. The teacher also gave suggestions to adjust the color of the question box in the "Dig for more information" column so that it does not contrast with the other boxes. Media experts provide input to change the introduction into a foreword, adding examples of species diversity in one family with some sample pictures.

Suggestions and comments from experts and practitioners become material for improving the development of teaching materials so that teaching

materials are obtained with the results of material completeness and better media appearance. Based on the advice of experts and practitioners, the revised teaching materials were then continued to the small-scale trial stage to assess the readability of the teaching materials. The product of teaching materials along with a readability assessment questionnaire was given to 16 students in class XI MIPA, to determine the level of readability and ease of students in understanding the instructions contained in the teaching materials. Based on the analysis of the readability assessment of teaching materials, it is known that the teaching materials developed have a very good level of readability and are easily understood by students with a percentage score of 81.75% with very good criteria. This is because students judge that the letters used in the teaching materials are clear and easy to read, the size and type of letters used are correct and not too many fonts are used. The contents of the material, pictures and illustrations contained in the teaching materials are very interesting with a consistent and harmonious layout, so that students do not get bored easily while learning to use teaching materials. Students also provide comments and suggestions on teaching materials, namely, some of the letters in the teaching materials are difficult to read because the background used has a motif, besides that the writing is too bold so it looks full. Students From a total of 16 students, 3 of them thought that there were still some images that were not clear in the teaching materials, and students wanted the pictures

in the teaching materials to be added to attract more students' attention to study the teaching materials. Students' comments and suggestions become a reference for improvement in the teaching materials developed, so that the teaching materials are feasible to be applied to students.

Improved teaching materials have a clear and easy-to-read font display by improving the appearance of the background on the teaching materials. The less clear pictures in the teaching materials have been replaced with better pictures and some pictures have also been added to support learning. Salyani, *et.al.*, (2018) explained that pictures can increase reading interest because pictures can help readers imagine, while imagination can help someone improve their memory performance and help remember words. Students enjoy learning to read with illustrated stories because of the more colorful display, interesting pictures, and simple sentences. Bua, *et.al.*, (2016). Therefore, with the inclusion of images, they can minimize their misunderstanding of the content of the text. Overall, the readability assessment of the developed teaching materials is good, the materials, content, pictures, and

supporting components of learning make students understand and interested in learning these teaching materials. Based on the results of the readability test and the results of the validation of the socio-scientific issue-based biodiversity teaching materials, it is very feasible to be applied in the biology learning process on biodiversity materials.

2. Effectiveness of teaching materials

This teaching material that is very valid and has excellent readability is next implemented in the learning process of biodiversity material in class X MIPA in four schools in Kudus District consisting of 125 students. The implementation phase aims to test the effectiveness of teaching materials in improving students' scientific literacy. Upgrade result students' scientific literacy was obtained from the scores pretest and posttest, then analyzed using the test N-gain. The calculation is N-gain used to find out how much literacy increases students' science after participating in learning using biodiversity teaching materials SSI based. Table 4 shows a recapitulation of the description of the value data analysis N-gain for each aspects of scientific literacy assessed.

Table 4. Description of the N-gain pretest and posttest of scientific literacy.

Aspects of scientific literacy	Mean pretest score	Mean posttest score	<i>N-gain</i>	Category
Science as the body of knowledge	62.13	80.8	0.49	Moderate
Science as a way of inquiry	64.48	82.88	0.52	Moderate
Science as a way of thinking	66.67	83.38	0.5	Moderate
Interaction of science, technology and society	65.07	84.53	0.56	Moderate

Based on the results of the N-gain analysis in Table 4 shows that the four aspects scientific literacy has increased in the moderate category. These results can be obtained because students learn to use teaching materials biodiversity based socio scientific issues that present clear and interesting learning material. The existence of a socio scientific issue approach in teaching materials allows students to make the right decisions, analyze, synthesize, and evaluate various issues that exist in society. Student experience in new and controversial issues in learning activities will foster skills scientific literacy (Widiyawati, 2020).

The activity of analyzing various issues and problems contained in the "What" column happens with our environment", and the column "Think

about it again" on SSI-based teaching materials aims to train students' scientific literacy, covering aspects of science as a way of thinking and science as a method of investigation. Students' scientific literacy ability can increase because in the material Teaching also provides discussion activities and answers the questions contained in the "Dig" column more information" and the "Think again" column. This activity aims to train scientific literacy skills aspects of science as the body of knowledge, science as a way thinking and science as a way of inquiry.

The application of SSI-based biodiversity teaching materials in learning can improve scientific literacy skills in the interaction of science, technology and society with moderate category.

This is because the teaching materials provide a column "Let's reflect", contains activities related to science and technology that are useful for public. In this activity students are trained to solve problems that exist in the classroom community environment by utilizing science and technology.

The application of SSI-based teaching materials in learning activities makes it easier for students in studying biodiversity. Examples of problem issues and pictures taken from the student environment, providing a contextual atmosphere so as to increase interest students in learning. Tsai, (2018) explains, problems that are close to experience student life can be incorporated into learning to increase student interest and turn it into active learning, so that it can encourage students to be involved in critical dialogue and train students' scientific competence.

In general, the research conducted can be declared effective in improving students' scientific literacy, because the four aspects of scientific literacy assessed experienced an increase in moderate category. So that teaching materials biodiversity based Socio Scientific Issue this can be an innovation in biology learning, where biology learning is not only emphasizes the achievement of learning outcomes only, but also the ability of students to analyze, investigate, and argue so that students can form concepts an independent science. Thus, it is expected that students' abilities do not only limited to theory but also able to understand the application of a science so that it can help overcome problems in the student environment.

CONCLUSION

Based on the analysis and discussion of the research results, it can be concluded that teaching materials Biodiversity based on the socio scientific issue is very feasible to be applied in Biology learning. Teaching materials have a readability level with very good criteria, which means: This means that teaching materials are easy to understand and read by students. The resulting teaching materials are also effective in improving four aspects of scientific literacy, namely science as the body of knowledge, science as a way of investigation, science as a way of thinking and the interaction of science and technology and society.

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