Vol 11(2) (2022): 130-141
DOI: http://dx.doi.org/10.24235/sc.educatia.v11i2.11891

SCIENTIAE EDUCATIA: JURNAL PENDIDIKAN SAINS

https://www.syekhnurjati.ac.id/jurnal/index.php/sceducatia

BioMagz with an Approach to Socio-Scientific Issues as a Learning Resource to Learn Environmental Change Materials to Improve Scientific Literacy

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article info

Article history:
Received: 23 Nov 2022
Received in revised form: 09 December 2022
Accepted: 26 December 2022
Available online: 31 December 2022

Keywords:
Biology learning
Biology magazine
Environmental changes
Scientific literacy
Socio-scientific issues

abstract

Students' limited learning resources result in low scientific literacy ability. Therefore, additional interesting learning resources are needed to improve the students' scientific literacy skills. One of the appropriate learning resources is BioMagz with an approach to socio-scientific issues. This research focuses on the material of environmental changes. This study aims to: (1) develop BioMagz with an approach to socio-scientific issues to improve the scientific literacy of environmental changes and (2) apply BioMagz with an approach to socio-scientific issues to increase the scientific literacy of environmental change materials. This development research employed the ADDIE model (analysis, design, development, Implementation, and evaluation) and was conducted at SMAN 1 Kadipaten. The experts' validation and students' responses show that the BioMagz with an approach to socio-scientific issues has a score of more than 86%. It concludes that BioMagz with an approach to socio-scientific issues is very feasibly implemented in learning. The hypothesis test on the scientific literacy ability variable has obtained a significant value of less than 0.005. This score indicates that H_0 is rejected and the use of BioMagz with an approach to socio-scientific issues in learning can increase students' scientific literacy skills.

1. Introduction

The real situation at school shows that students conduct biology learning activities only using textbooks provided by the government as a learning resource. Monotonous and complex learning resources, such as textbooks, can cause students to lose interest in reading. This postulation is supported by Rifqiawati et al. (2020) who state that students' low reading interest and less various learning resources can demotivate students to learn and lower their reading literacy. Moreover, students' low reading interest declines their scientific literacy skills, which are crucial for them. Students who have good scientific literacy skills will have strong scientific thoughts and attitudes and can effectively communicate knowledge and research results to the general public (Yuliyanto & Rohaeti, 2013). Moreover, they can use science concepts comprehensively and have science process skills to assess and decide the relationship between social and technological development.

In other words, people with scientific literacy skills can use their scientific concepts significantly and are not easily provoked by social issues without empirical evidence.

Ardianto and Rubini (2016) assert that scientific literacy should be developed because it can provide satisfaction and personal pleasure that arises after understanding and studying science. Ardianto and Rubini (2016) add that everyone needs information and scientific thinking for decision-making and should involve their abilities in public discourses and debates. Scientific and technological issues as well as scientific literacy are important for work; thus, people are required to study science, reasons, creative thinking, decision-making, and problem-solving. This explanation reaffirms that scientific literacy has many benefits and wide uses so that students must have scientific literacy skills to apply in their daily life.

A solution to foster students' interest in reading and increase their scientific literacy is to provide alternative learning resources that combine technological development with education to produce more flexible, interesting, and understandable learning resources for students. If textbooks and worksheets are complex and monotonous, a learning resource in the form of magazines can become more interesting for the students. Pratiwi et al. (2018) define magazines as print media for mass communication, which functions to present actual, factual, up-to-date information, enrich the treasury of knowledge, and increase the motivation of readers. BioMagz is an abbreviation of biology magazines and refers to a magazine that contains biology materials, serves as an alternative source of independent learning, and provides readers with fun learning activities. Asfuriyah and Murbangun (2015) explain that BioMagz constitutes the information media to convey the news about scientific concepts, including biology.

BioMagz can establish biology learning activities anywhere, either in the classroom or outside the classroom. In other words, BioMagz offers flexible and not rigid biology learning. The development of BioMagz has several advantages. First, BioMagz follows the presented content. Second, BioMagz is completed with attractive pictures. Third, BioMagz has additional content in the form of the latest educative information, which usefully broadens students' insights, evaluates students' points of view, and measures their knowledge. This statement is supported by Rifqiawati et al. (2020) who discover that reading literacy skills of the students at SMAN 7 Pandeglang have increased after they implement biology magazines for reading because the magazines' attractive appearance provides visual stimulation to encourage students' interest in reading, and the magazines' concise content shortens the learning process.

Environmental changes frequently occur today. Schools and learning activities are educational tools to convey the importance of preserving the environment. Environmental change material is one of the materials included in the core competencies and basic competencies that must be achieved by class X students at senior high schools. Environmental changes are closely related to daily life and include problems such as garbage and waste. These problems result in environmental changes and global climate changes. To enable students to understand the material of environmental changes, learning resources should help the students understand these problems, acquire the ability to explore concepts and raise their curiosity to learn more comprehensively about this material. Therefore, this study has developed the BioMagz learning resource to explain the material of environmental changes.

Wadas Village of Bener District of Purworejo Regency of Central Java has high biodiversity. This village produces several forestry and plantation commodities, such as *sengon*, teak, mahogany, coconut, acacia, banana, palm sugar, cardamom, and cloves. Moreover, this village annually produces agricultural commodities. Approximately 405,820 hectares of this village contain andesite rocks; This number is similar to 40 million cubic meters. Andesitic rock is a type of intrusive volcanic rock with an intermediate composition and aphanitic textures to porphyritic

textures. This andesite stone is very good to build foundations, concrete aggregates, floor tiles, and wall tiles. These rocks have strong and durable durability.

The Wadas conflict is inseparable from the government's plan to build the Bener Dam since 2017; this dam is 10 kilometers from Wadas Village. The Bener Dam is a national strategic project stipulated in Presidential Regulation Number 58 of 2017. The government is aware of the presence of andesite rock in the Wadas area so that the government plans to mine 15.53 million cubic meters of andesite rock in 145 hectares of land for 30 months. The type of mining in Wadas is a quarry or open pit mining (dredged without waste). Unfortunately, the Wadas people have refused this mining plan, resulting in a serious conflict between the government and the local community. The residents refuse this plan because mining activities will negatively endanger the environmental or ecological aspects. Moreover, the residents are worried that mining activities will damage 28 springs in the village, and the village will become more prone to landslides. The Regional Regulation on the 2011-2031 Purworejo Regency Spatial Plan reports that all areas in Bener District, including Wadas Village, are categorized as a landslide-prone area.

The basic competency in the material of environmental change is analyzing data on environmental changes, the causes of these changes, and the emerging impacts on life. Based on the environmental change material, students are expected to be able to analyze environmental problems. Therefore, environmental learning should be designed and implemented through learning strategies to meet contextual needs and enable students to deal with real problems in their environment, develop knowledge, values, attitudes, and problem-solving skills, make decisions, and concern for the environment. The learning strategy potentially applied is the socio-scientific issues approach. Callahan (2009) determines socio-scientific issues as a learning strategy that presents science material in the context of social issues and involves moral and ethical components. Learning with a socio-scientific approach and socio-scientific issues can increase scientific literacy and critical thinking skills as well as provide interesting contexts in science and science learning (Borgerding & Dagistan, 2018). Learning activities using socio-scientific issues will increase students' understanding of scientific concepts related to social values and other scientific values (Santika et al., 2018). Socio-scientific issues about the material of environmental changes are presented in BioMagz. This kind of magazine attracts students' attention to study science. Learning with a socio-scientific issue approach is useful for students because they can develop their thinking skills by analyzing a problem, arguing about a problem, and making a decision. Thinking skills can improve students' scientific literacy skills. This postulation is supported by Sadler et al. (2016) who state that socio-scientific issues can attract students' attention to learn science and increase their understanding of science. Meanwhile, Gobet et al. (2019) have discovered that a strong strategy for learning science and developing scientific literacy is a socio-scientific issue. Based on this phenomenon, a biology magazine (BioMagz) with a socio-scientific issue approach is employed by the students as an alternative source of learning biology. BioMagz with a socio-scientific issue approach is expected to help students improve their scientific literacy.

2. Method

This research and development (R & D) study employed the development model developed by Dick and Carey (1996), namely the ADDIE model (analysis, designs, development, implementation, and evaluation). The steps of this research are as Figure 1.

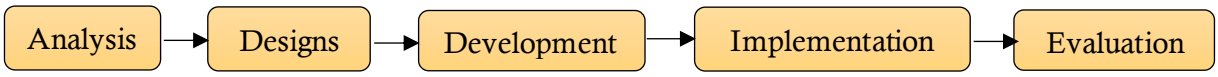

Figure 1. Research and development design (R & D) with the ADDIE model (Dick and Carey, 1996)

The development of BioMagz with an approach to socio-scientific issues and the ADDIE model is described in the Figure 2.

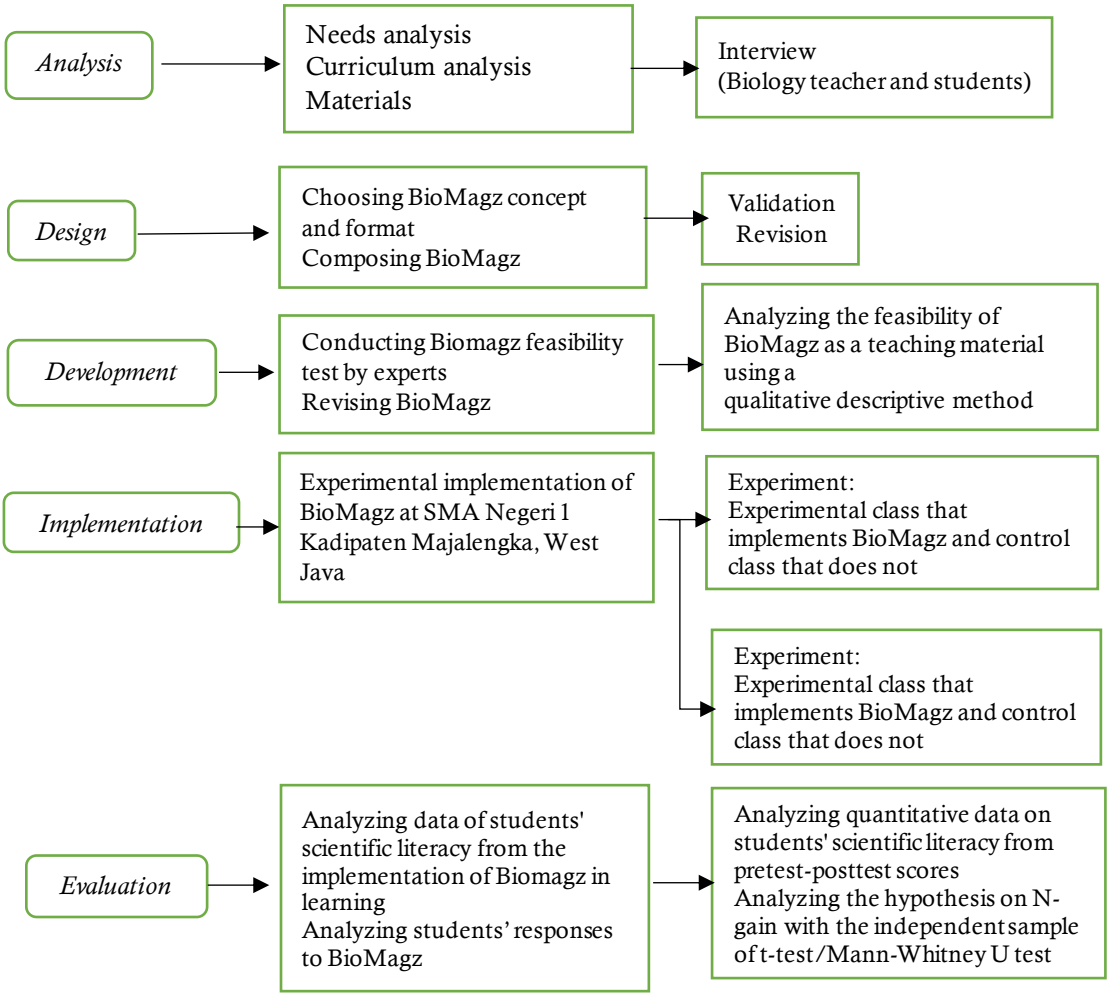

Figure 2. Development procedures of BioMagz

This development research employed the ADDIE stages to analyze qualitative and quantitative data. These qualitative data were gained from the definition, design, and development stages. Meanwhile, the quantitative data were gained from the implementation stage. Descriptive qualitative data at the design and development stages were in the form of the feasibility of BioMagz applied when learning the material of environmental changes. At the design stage, the feasibility of BioMagz was gained from expert judgment. This study involved material experts who judge biology, language experts who asses the use of Indonesian in BioMagz, and media experts who assess the visualization of BioMagz. Meanwhile, at the development stage, the feasibility of BioMagz was gained from the assessment by several biology teachers who used BioMagz.

At the implementation stage of BioMagz learning, the students' scientific literacy was assessed by observing their use BioMagz. Meanwhile, the students' learning outcomes were assessed using the scientific literacy test in the form of multiple choices. The scientific literacy test instrument employed the PISA framework (OECD, 2018), which consisted of scientific knowledge or concepts, scientific processes, and situational or contextual domains. This test instrument had been tested before being implemented in this research. The test result shows that the instrument

has valid and reliable constructions and content. The scientific literacy of the experimental and control classes was analyzed using the Mann-Whitney U test. At the evaluation stage, students' responses to the use of BioMagz were measured descriptively using a questionnaire.

3. Results and Discussion

This research employed a research and development design and the ADDIE model developed by Dick, and Carey (1996). This development research consists of five important stages and follows the extension of the ADDIE model. These stages are analysis, design, development, implementation, and evaluation. This research has produced a learning resource product in the form of BioMagz with an approach to socio-scientific issues to improve students' scientific literacy skills.

The first stage is the analysis stage which includes needs analysis and material analysis. The need analysis was carried out by interviewing biology teachers and students at SMAN 1 Kadipaten. The interviews have revealed that students in the biology learning process have limited learning resources because their learning resource is only a textbook provided by the government. Such a condition lowers students' interest in reading and scientific literacy skills. This finding agrees with Rifqiawati et al. (2020) who state that students' low reading interest and less various learning resources can be caused by low learning motivation and reading literacy. Such problems can be solved by developing alternative learning resources that combine technological developments with education. This development will produce an interesting, flexible, actual, factual, and understandable learning resource. Based on the aforementioned explanation, the researchers developed learning resources in the form of biology magazines (BioMagz). Retnosari (2016) state that BioMagz is attractive because it displays pictures, has unique shapes, and is easily conducted anywhere. Moreover, BioMagz consists of a coherent sequence of material to increase students' interest in reading and scientific literacy abilities.

The next analysis stage is material analysis, which consists of curriculum analysis and material concept analysis. The developed BioMagz adapts to the 2013 curriculum. The stage of the material analysis began with determining the material used in BioMagz. The researchers selected three materials on environmental changes from literature studies and social science issues developed in society. The issues are about environmental changes in Wadas as a result of the discovery of adhesive stones that will be exploited by the government because these stones constitute high-value natural resources.

The second stage is the design to develop BioMagz. The design processes for developing BioMagz include concept selection and format selection. The concept selection stage has produced the BioMagz, which applies an approach to socio-scientific issues to increase students' scientific literacy. This finding agrees with Borgerding and Dagistan (2018), who deploy that learning with an approach to socio-scientific issues can increase scientific literacy and critical thinking skills as well as provide an interesting context for learning science and science. The choice of BioMagz format with an approach to socio-scientific issues was developed using Microsoft Word and the Canva application because Canva offers many interesting designs for magazines. The BioMagz was developed with the size of A4 (21 cm x 29.7 cm). Furthermore, BioMagz is made in an electronic version in the form of a website Flip Book PDF that can be accessed on mobile phones. The link to this website is bit.ly/BiologyMagazines. This electronic version enables the students to access it outside the learning, is more practical and flexible, and can be read anytime and anywhere. The displays of printed and electronic versions of BioMagz are shown in Figure 3. The designed draft of BioMagz has been validated by several experts.

Figure 3. Displays of BioMagz in printed and electronic versions

BioMagz contains material on environmental changes with an approach to socio-scientific issues. This BioMagz has a visual representation of adhesive rocks in Wadas Village and contains discourses of social conflicts in the community. The display of adhesive rock features and the discourse of social conflicts in Wadas village are presented in Figure 4.

Figure 4. Displays and discourses in BioMagz representing adhesive rocks and social conflicts

At the design stage, the developed BioMagz was validated by several experts to test its feasibility. These experts are material experts, media experts, and linguists. The eligibility criteria of BioMagz include the accuracy of BioMagz with students' needs as a learning resource. The results of the feasibility test of BioMagz are presented in Table 1.

Table 1. Results of feasibility test of BioMagz

Expert	Score	Criteria
Material concepts	91.60	Worth to implement
Media representation	87.14	Worth to implement
Indonesian language	95.00	worth to implement

Table 1 shows that BioMagz's approach to socio-scientific issues on environmental changes has very appropriate criteria for a learning source used by students. This statement is supported Riduwan (2013) who proposes quality criteria for eligibility. The criteria state that scores of 81-100 have worth criteria to implement. This concludes that the scores of BioMagz have been categorized it as worth to implement during the learning process of environmental changes.

The next stage is the development stage. This stage was conducted because biology teachers at the research site assiduously implement BioMagz in the learning process. The feasibility of BioMagz was assessed by several biology teachers at SMAN 1 Kadipaten. The result shows that BioMagz is suitably used as a learning resource to learn the materials of environmental changes. BioMagz is appropriate to use as a learning resource because they have four major advantages (Asfuriyah & Murbangun, 2015). First, students can learn and progress according to their pace even though at the end of the learning, all students are expected to successfully master the presented topics. Second, students will follow the sequence of logical thoughts by repeating the material. Third, the combination of text and images can add to the learning source's attractiveness and facilitate the students to understand the information presented in verbal and visual formats. Fourth, BioMagz contains information that applies to developments and new findings and provides a learning supplement for students.

The feasibility of BioMagz was assessed by experts and biology teachers. The result shows that the highest score is gained by the language aspect. Kristian and Suyono (2016) explain that good learning resources can adapt to effectively use language to develop students' social, intellectual, and emotional skills, communicative languages, and integration between chapters and between paragraphs. Based on these situations, BioMagz with the approach of socio-scientific issues pays attention to five aspects: (1) choosing simple words, (2) using a readable font, (3) not using dirty and harsh words, (4) using communicative language to create direct communication with readers, and (5) building relationships and integrations between chapters and between paragraphs. Short, straightforward, and concise sentences enable the students to understand a reading text. Moreover, difficulty levels of reading materials and examples should consider students' abilities. This proves that BioMagz is suitably implemented in the class because BioMagz uses good Indonesian rules and linguistic aspects; thus, everyone can easily understand its messages BioMagz.

The next stage is the implementation stage to increase students' scientific literacy. The electronic version of BioMagz in the form of a link enables the students to flexibly access it on a mobile phone anytime and anywhere. Such learning is commonly called mobile learning (m-learning). This finding agrees with Jazuli et al. (2018) who have proven that learning using a mobile phone or mobile learning facilitates students to learn anywhere and anytime. Electronic BioMagz enables teachers and students to access and use it anywhere and operate it easily. Moreover, Electronic BioMagz helps the students to learn more easily. Media experts believe that BioMagz has an attractive-visual appearance because it uses appropriate layouts, colors, sizes, and font types that do not tire its readers. The implementation stage, BioMagz with an approach to socio-scientific issues of environmental changes is employed in the learning to improve students' scientific literacy skills. Students' scientific literacy is measured by observing learning activities. The results of this observation are presented in Table 2.

Table 2. Average scores of students' learning activities

Classes	Average scores	Criteria
Experiment	86.30	Very good
Control	51.48	Enough

Table 2 shows that the experimental class that applies BioMagz has a higher scientific literacy score of 86.3 than the control class that does not apply BioMagz to learn environmental changes. If students reach a value of 80-100, they are classified as having a very good criterion of scientific literacy skills (Trianto, 2013). In contrast, if the students reach the average scores of scientific literacy skills of 51-60, they are classified as having a enough criterion (Trianto, 2013). These findings conclude that students in the experimental class who apply BioMagz in their learning

activities have better scientific literacy skills than the students in the control class. This proves that using BioMagz to learn materials about environmental changes can increase the students' learning activities and scientific literacy.

Arizen and Suhartini (2020) explain that the presentation of socio-scientific issues stimulates students to question the stages of the occurrence of environmental issues or problems, the causes of these phenomena, and the consequences of the continuous occurrence of environmental problems. The use of BioMagz in learning activities enables students to comprehensively analyze the background of environmental changes in Wadas Village. Moreover, they can find information, such as data and evidence of the conflict in Wadas Village based on literature sources. Such an activity will improve students' ability to read and interpret the collected data or information. This collected information and data are then compiled and discussed to conclude the arguments and explain environmental issues or problems surrounding the students. After gaining findings from investigations, the students can make solutions for these environmental problems. In other words, BioMagz with the approach to socio-scientific issues can increase students' scientific literacy.

The students' scientific literacy was also measured using multiple-choice test instruments before (pretest) and after the learning (posttest) to reveal the students' learning outcomes. Afterward, the students' scientific literacy was tested to reveal the normality and homogeneity. The findings of the scientific literacy test show that the data are normally distributed and homogeneous. Therefore, the t-test was then employed to examine scientific literacy. The N-gain test was conducted to find out if the use of BioMagz with an approach to socio-scientific issues during learning brings significant differences. The average N-gains in the control and experimental classes are presented in Table 3.

Table 3. Average scores and N-gain of scientific literacy

Classes	Average scores		N-gain	
	Pre-test	Post-test	Average	Criteria
Experiment	31.85	79.81	0.71	High
Control	36.67	48.52	0.16	Low

Table 3 shows that the experimental class and the control class have different average scores in scientific literacy. The experimental class has a higher score in scientific literacy than the control class. This finding proves that BioMagz can increase students' scientific literacy. The two groups also have different average scores of N-gain. The experimental class has a high criterion of the average N-gain while the control class has a low criterion of the average N-gain. This result proves that BioMagz increases the students' scientific literacy.

The normality and homogeneity tests have discovered that one value is not normally distributed and is homogeneous. Therefore, the non-parametric test was employed to examine the hypothesis. The non-parametric test used in this study is the Mann-Whitney U test to find out if BioMagz with an approach to socio-scientific issues can improve students' scientific literacy skills. The results of the Mann-Whitney U test are presented in Table 4.

Table 4. Mann Whitney U test results

Data	Result
Man Whitney test	13.500
Asymp. Sig. (2-tailed)	< 0.001
Conclusion	There is an increase.

Table 4 shows that the value of the Mann-Whitney U test is seen from the asymp. Sig. value (2-tailed). The Mann-Whitney U test has obtained results of <0.001. This result indicates that H_0 is rejected while H_1 is accepted. Moreover, this result shows that BioMagz with an approach to

socio-scientific issues could increase the students' scientific literacy skills. This finding is in line with Kartika et al. (2019) who have discovered that teaching materials based on socio-scientific issues greatly influence and increase students' scientific literacy, in terms of competency and attitude aspects. Moroever, the result of this research is in line with Dalaila et al. (2022) who have proven that teaching materials with an approach to socio-scientific issues can improve students' scientific literacy abilities because this approach involves knowledge about controversial themes in society, dilemmas, and social issues. Therefore, the students are trained to dialogue and debate the importance of dealing with socio-science issues. Moreover, this approach integrates the content with science literacy to analyze social issues about science. Thus, the students can significantly generate aspects of evidence-based reasoning. These findings are supported by research that shows that the use of socio-scientific issues in learning can improve students' scientific arguments (Siska et al., 2020; Ekanara & Isfiani, 2020). The use of socio-scientific issues in learning can increase scientific literacy (Saija et al., 2022; Rahayu et al., 2022; Li & Guo, 2021; Wiyarsi et al., 2021).

The implementation of BioMagz with an approach to socio-scientific issues in learning facilitates the students to study material on environmental changes. Examples of problems and pictures in BioMagz are taken from the students' environment. This step provides a contextual atmosphere to increase students' interest in learning activities. Rohmah et al. (2022) opine that problems close to students' life experiences can escalate their interest in learning and their learning activities. As a result, the students can explore their knowledge to become active learners, are encouraged to engage in critical dialogue, and are trained to use their scientific competence. The results of the study show that learning socio-scientific issues can facilitate reasoning on socio-scientific issues, examining problems from various perspectives, skepticism about information, and developing students' character and values (Lee et al., 2012). The use of socio-scientific issues in learning can increase students' understanding of science (Tsai, 2018), awareness of the environment (Hadzigeorgiou, & Skoumios, 2013), and environmental literacy (Kinslow et al., 2019)

This evaluation stage is the final stage to revise the developed product. In the evaluation phase, the students filled out a response questionnaire about learning using the BioMagz with an approach to socio-scientific issues to increase their scientific literacy skills. This response questionnaire was distributed to the students in the experimental class. This response questionnaire aims to find out if learning using BioMagz with an approach to socio-scientific issues is significant for the students. The results of the questionnaire analysis on students' responses are presented in Figure 5.

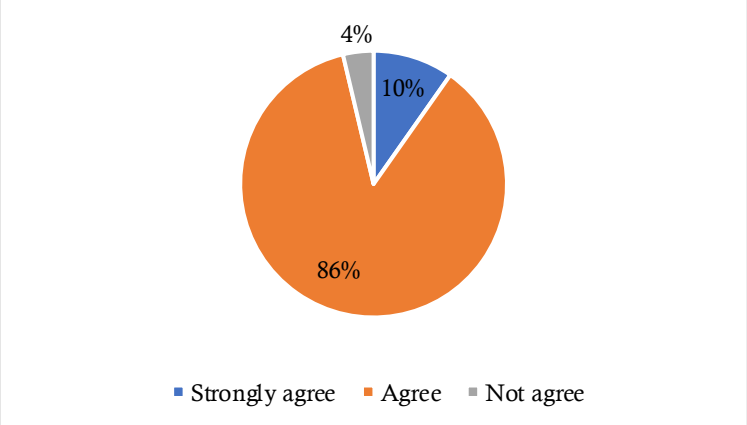

Figure 5. Results of questionnaire analysis on students' response

Figure 5 shows the results of a questionnaire of students' responses to the BioMagz with an approach to socio-scientific issues. These results show that the students positively respond to the BioMagz with an approach to socio-scientific issues because many students strongly agree with the questionnaire. These findings are supported by Purwanto (2008) who states that BioMagz with an approach to socio-scientific issues has very good assessment criteria. The students' positive responses show that they feel happy and are interested in learning using BioMagz. Moreover, they agree that the application of BioMagz can improve scientific literacy skills. They argue that the design of BioMagz is very interesting because it is designed with beautiful and various colors. Thus, they are not bored using the book for learning. This shows that BioMagz with an approach to socio-scientific issues has very good criteria for learning. This finding is confirmed by Retnosari (2016) who have revealed that BioMagz has attractive pictures, unique shapes, easiness to carry anywhere, and a coherent sequence of material that can increase students' interest in reading and scientific literacy abilities. This is supported by research findings which show that students are enthusiastic in learning and help master the material better (Saija et al., 2022). Moroever, the students and education practitioners prefer the electronic version of BioMagz because it is downloadable in a PDF version, can be supported by Android and IOS smartphones, is easily distributed, and consists of files with small sizes so that users are not burdened.

4. Conclusion

BioMagz is developed using the 4D model and applies a socio-scientific issue approach. This magazine is based on an analysis of social conflicts due to local potential in Wadas Village that cause environmental changes. These conflicts become a learning resource that is very feasibly implemented to learn the concept of environmental changes. Several indicators of socio-scientific issues discussed in BioMagz and implemented in learning can increase the students' scientific literacy. This research implies that learning resources in the form of magazines constitute innovative and interesting teaching materials for the students because the characteristics of these magazines are not arbitrarily similar to textbooks or teaching material modules. This study recommends that BioMagz is implemented in other secondary schools. Thus, the results of this study more stably reveal students' scientific literacy.

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