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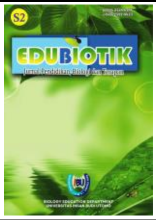

Research Article

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Developing a classification of living things e-module with a jelajah alam sekitar approach to help students reduce misconceptions and strengthen scientific literacy

Khofiatul Illah [1,a], **Rizki Nor Amelia** [1,b,*]

[1] Department of Science Education, Universitas Negeri Semarang, Semarang, Indonesia
Email: khofiatulillah@students.unnes.ac.id [1,a], rizkinoramelia@mail.unnes.ac.id [1,b,*]
* Corresponding author

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ABSTRACT

One strategy to reduce misconceptions and strengthen science literacy in the classification of living things is to facilitate students with contextual learning resources. Therefore, this study aims to develop an e-module as a learning resource that is integrated with the approach of Jelajah Alam Sekitar (JAS) so as to enable students to understand science concepts through collaborative practices of nature exploration. This research method is research and development using the 4D development model (define, design, develop, and disseminate). Class VII students at MTs Ishthifaiyah Nahdliyah were involved as samples with details of 180 students as the standardization test sample of the integrated science misconception-literacy instrument, 29 students as the e-module readability sample, and 32 students as the e-module implementation sample. Data collection was carried out using interviews, a questionnaire, and student science literacy and misconception tests. The instruments used included interview guidelines, e-module characteristic questionnaires, e-module feasibility questionnaires, student response questionnaires, and pretest-posttest questions. Data analysis for the effectiveness of the e-module on student science literacy and misconceptions was performed using a paired t-test. The developed JAS E-module proved to be very feasible in terms of material concept, presentation, language, and graphics, and had excellent characteristics in terms of module characteristics, JAS components, and activities that contained indicators of misconceptions and science literacy. In addition, based on the results of the effectiveness test, in general, the e-module proved significant in reducing misconceptions ($p<.05$; $t=-4.818$; $df=31$) and strengthening students' science literacy ($p<.05$; $t=4.636$; $df=31$). Thus, this development contributes to improving science learning, especially in reducing misconceptions and strengthening science literacy.

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INTRODUCTION

The 21st-century learning is designed to be student-centered and directed towards activities that can hone their abilities and skills (Elitasari, 2022). One of the essential skills greatly needed by students in the 21st century is scientific literacy, which is one's ability to use their knowledge to identify problems, explain phenomena scientifically, and create conclusions based on available evidence (Muliani et al., 2023). Therefore, the educational world is currently actively conducting various developments aimed at improving scientific literacy among students (Situmorang, 2016), as several countries have made scientific literacy one of the main objectives in their science education (Sumarni et al., 2017). Although findings on scientific literacy capabilities can vary (Maulina et al., 2022; Mellyzar et al., 2022; Muliani et al., 2023; Nurazizah et al., 2022), the consistently low level of students' scientific literacy in Indonesia based on PISA results over the years remains a distinct problem (Bilad et al., 2024; Yusmar & Fadilah, 2023). The use of inappropriate teaching materials and misconceptions among students are suspected to be contributing factors to students' low scientific literacy (Rokhim et al., 2023; Suparya et al., 2022).

Misconception is defined as an incorrect or inaccurate understanding of a concept (Arda & Anita, 2021) and has become a common problem experienced by students in science learning, especially in biology materials (Samiha et al., 2017; Yanti et al., 2019). Research by Dwilestari & Desstya (2022) shows that 60% of students scored below the minimum completion criteria due to misconceptions. These misconceptions are highly dangerous and can persist continuously, necessitating action to reduce them. Integrating technology in the development of teaching materials (such as e-modules) can be a solution to address misconceptions while strengthening students' scientific literacy (Nurrahmah & Sukarmin, 2023; Rustono & Buchori, 2023; Suparya et al., 2022). E-modules are digital-based teaching materials whose use is not limited by space and time (Parapat et al., 2024) and function to display messages in the form of text, images, and audiovisual content in the learning process (Putri & Erita, 2023). The use of e-modules will be more effective when combined with the Jelajah Alam Sekitar (JAS), also known as the environmental exploration approach (Darwati et al., 2023) because this approach utilizes the surrounding environment, such as physical, social, cultural, and technological environments (Alimah & Marianti, 2016) with six main components as its characteristics, such as exploration, constructivism, science process, learning community, bioedutainment, and authentic assessment (Lestari et al., 2024).

Based on interviews with science teachers and a sample of seventh-grade students, the majority of students suffer from misconceptions in the classification of living things, such as reptiles are fierce animals and whales are fish because they live in water and their weak scientific literacy capabilities cause them to encounter many difficulties when processing and understanding the information they receive. The results of scientific literacy support this, and misconception pretests in pre-research, which showed 8.6% of students had high scientific literacy (conceptual), 20.3% at the medium level (functional), and 71.1% of students had low scientific literacy (nominal). Additionally, misconceptions were found in several indicators, including distinguishing living things from non-living things (3.13%), using the binomial nomenclature system (15.63%), analyzing the characteristic features of each kingdom (10.94%), using determination keys (10.94%), and explaining the role of living things in daily life (15.63%). These results are reinforced by the high findings of misconceptions occurring in the classification of living things material (Agustina & Indana, 2022; Gultom, 2023; Yona & Ilhami, 2022). Several factors can contribute to these misconceptions, such as students' errors in concept generalization, the use of conventional learning methods such as lectures, and teaching materials that are not equipped with illustrations or images that can clarify concepts (Jayanti & Susantini, 2021; Muryani et al., 2022; Rosita et al., 2020). Therefore, innovation in teaching materials is needed to facilitate the strengthening of scientific literacy while simultaneously reducing misconceptions in the classification of living things material.

The needs analysis concluded that existing e-modules have not been able to accommodate scientific literacy while simultaneously reducing misconceptions. Although several studies have demonstrated the effectiveness of the JAS approach and the use of e-modules in science learning separately, there remains a gap in developing e-modules that comprehensively integrate the JAS approach to strengthen scientific literacy and reduce student misconceptions. While the JAS approach has demonstrated effectiveness in improving learning activities (Amiruddin, 2021; Mansur & Xaverius, 2020) and general learning outcomes (Amiruddin, 2021; Enengsi, 2024; Mansur & Xaverius, 2020; Putri & Erita, 2023; Rumawir et al., 2024). No research has been conducted on the effectiveness of the JAS approach in addressing misconceptions. Research by Kaniyah et al. (2022) developed a problem-based learning science e-module that effectively improved scientific literacy but failed to address misconceptions in the subject matter. Meanwhile, research by Ule et al. (2021) on developing teaching materials in the form of JAS-based module books, remained limited to conventional learning without adequate digital media support. Although the JAS-based module could improve student learning outcomes, its effectiveness in strengthening scientific literacy and reducing misconceptions remains unknown.

To address this research gap, this study aims to develop an innovative JAS approach-based e-module specifically designed to strengthen scientific literacy while simultaneously reducing misconceptions related to the classification of living things. JAS possesses significant pedagogical potential, as it not only emphasizes instant knowledge and understanding of scientific concepts and processes (Roja, 2019), but also provides direct experience to students by involving the surrounding environment. This enables students to actively engage in learning, training them to observe, analyze, and conclude scientific information. Therefore, this research is uniquely positioned to bridge the identified gap by developing a JAS-based e-module that strategically integrates the advantages of digital learning with environmental exploration, supported by educational games and content specifically designed to clarify concepts where misconceptions in the classification of living things frequently occur.

RESEARCH METHODS

This research is a development study using the 4D development model (Thiagarajan, 1974), which consists of define, design, development, and disseminate (Figure 1). In the development stage, the implementation was conducted to test the effectiveness of the developed e-module using a one-group pretest-posttest design (Table 1).

Table 1. One-Group Pretest-Posttest Design

Group	Pretest	Treatment	Posttest
Experiment	O1	X	O2

All seventh-grade students of MTs Ishthifaiyah Nahdliyah distributed across six classes were involved as the population, resulting in instrument trial samples (180 students), e-module readability trial samples (29 students), and implementation stage samples (32 students) selected through a cluster random sampling technique. The instruments used in this research included interview guidelines for teacher and student needs analysis during pre-research, an e-module characteristics questionnaire (i.e. material concepts, presentation, language, and graphics), an e-module feasibility questionnaire (i.e. module characteristics, JAS components, and activities containing misconception and scientific literacy indicators), student readability response questionnaire, and integrated four-tier multiple choice test questions constructed based on scientific literacy indicators (content, process, and context aspects) and learning outcome indicators for the classification of living things material for misconception detection.

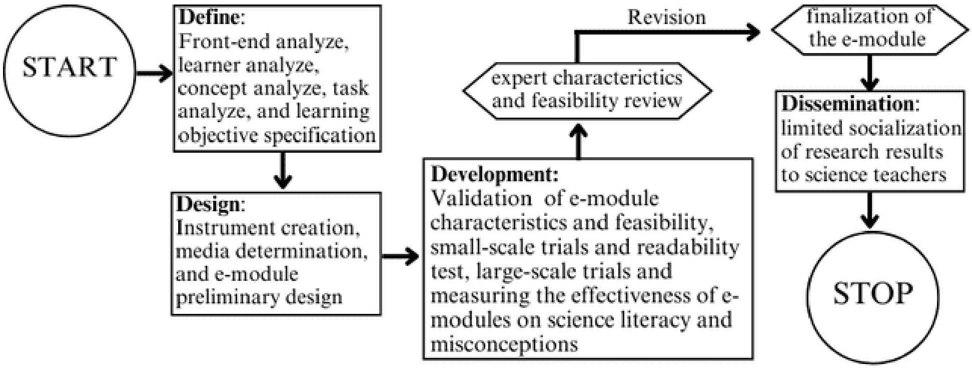


Figure 1. Procedure Research (Modification from Yulia et al. (2024))

All questionnaire instruments were constructed using four scales (1 = strongly disagree, and 4 = strongly agree) and interpreted into five categories (Table 2). In contrast, the test instrument used was an integrated instrument to measure scientific literacy and detect misconceptions that had proven valid ($\overline{VI}$=.91) and reliable (α-SL=.86 and α-MC=.70), where the detailed development procedure is discussed in a separate article. Measurement with this integrated instrument certainly helps teachers in terms of instrument efficiency, cost, and time. The integration instrument was arranged in the form of a four-tier multiple choice because it can determine the level of scientific literacy through student conception categories (Krisdiana et al., 2018), thus facilitating the identification of which materials need strengthening to prevent misconceptions (Wola et al., 2020). Data analysis to address hypotheses related to the effectiveness of e-modules in strengthening scientific literacy and reducing student misconceptions was conducted through paired t-tests using the Jamovi program.

Table 2. Categorization of Characteristics, Feasibility, and Readability of E-Modules

Formula Categorization	E-module Characteristic	E-module Feasibility	E-module Readability	Interpretation
$X \leq M_i - 1.5\ SD_i$	X≤40.25	X≤36.75	X≤17.5	Very Poor
$M_i - 1.5\ SD_i < X \leq M_i - 0.5\ SD_i$	40.25<X≤51.75	36.75<X≤47.25	17.5<X≤22.5	Poor
$M_i - 0.5\ SD_i < X \leq M_i + 0.5\ SD_i$	51.75<X≤63.25	47.25<X≤57.75	22.5<X≤27.5	Moderate
$M_i + 0.5\ SD_i < X \leq M_i + 1.5\ SD_i$	63.25<X≤74.75	57.75<X≤68.25	27.5<X≤32.5	Good
$X > M_i + 1.5\ SD_i$	X>74.75	X>68.25	X>32.5	Excellent

Note: X = Score obtained; M_i = Ideal mean; SD_i = Ideal standard deviation (Azwar, 2012)

FINDING AND DISCUSSION

This research aims to determine the characteristics, feasibility, and effectiveness of the JAS-approached e-module in improving scientific literacy and reducing student misconceptions using the 4D development model. The define stage consists of five activities (i.e., front-end analysis, student analysis, concept analysis, task analysis, and learning objective specification), which generally conclude that science learning in living things classification material at MTs Ishthifaiyah Nahdliyah requires learning resources that can facilitate students in strengthening literacy and reducing misconceptions. The design stage was carried out by creating a JAS-approached e-module prototype with key components (e.g., front and back covers, main menu, information menu, material menu) that can be seen in Figure 2, which are appropriate and relevant to teacher and student needs. The e-module design was created with Canva and exported to Heyzine to add interactive features such as "go to page", "video link", and "navigation features". The e-module was designed to be easily accessible without installing applications and consuming device storage space by being accessible through a link connected to Heyzine.

(a) (b) (c) (d)

Figure 2. (a) E-Module Cover, (b) E-Module Main Menu, (c) E-Module Information Menu, (d) E-Module Material Menu

The development stage consists of an assessment of e-module characteristics and feasibility by experts (2 science education lecturers from Universitas Negeri Semarang and 2 science teachers from MTs Ishthifaiyah Nahdliyah), e-module revision according to expert suggestions, small-scale trials (e-module readability), and e-module finalization. Aspects assessed in the validation of e-module characteristics (Table 3) consist of e-module characteristic aspects using e-module characteristic criteria (i.e., self-instruction, self-contained, stand-alone, adaptive, and user-friendly) according to Kokasih (2021), and include JAS components, scientific literacy indicators, and misconception reduction.

Table 3. E-Module Characteristics Assessment Results

Expert	Characteristics of E-Modules	JAS components	Scientific Literacy Indicators	Reduce Misconceptions	Total Score	Conclusion
E1	36	24	28	4	92	Excellent
E2	36	24	28	4	92	Excellent
E3	31	23	25	4	84	Excellent
E4	36	24	28	4	92	Excellent
Mean	34.75	23.75	27.25	4	90	Excellent

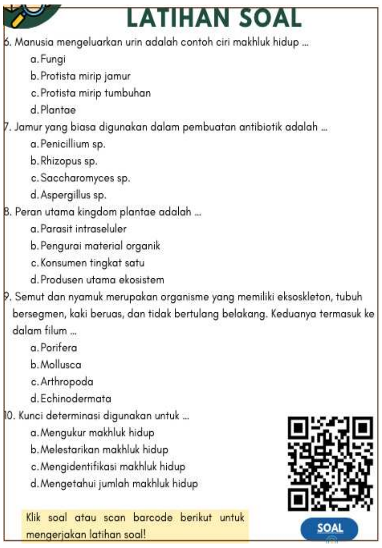
The first aspect of e-module characteristic assessment, namely e-module characteristics, received an excellent rating and is described as follows. Self-instruction means the e-module must have clear instructions so students can easily use the e-module independently without depending on others, such as teachers (Kokasih, 2021; Pratama et al., 2023). The developed e-module has excellent self-instruction aspects as evidenced by clear and detailed learning achievement indicators and objectives, complete and comprehensive material descriptions, and exercise questions that students can use to apply their understanding of the material studied. Self-contained means the material in the e-module must be presented comprehensively and systematically so students can study the material thoroughly (Pratama et al., 2023). The self-contained characteristic is reflected in the developed e-module with excellent criteria, where the material in the e-module is complete, according to student needs, and the order of material presentation is done systematically according to the scientific hierarchy (Kokasih, 2021). The material is presented from characteristics that distinguish living things and non-living things, living things classification systems then continued with a discussion of characteristics and roles from simple to more complex kingdoms (i.e. kingdom eubacteria, archaebacteria, protista, fungi, plantae, and animalia), and the last material is how to make and use determination keys to classify living things.

The developed e-module demonstrates excellent characteristics in terms of its stand-alone, adaptive, and user-friendly qualities. The stand-alone nature ensures students can comprehensively access and utilize the material without requiring additional external teaching materials. This characteristic is supported by Talan & Widayati (2023), who emphasizes that effective e-modules must function independently to maximize learning efficiency. Furthermore, the e-module meets adaptive criteria with an excellent rating as it can be seamlessly used across various technology devices (computers, laptops, smartphones, and tablets) regardless of specific operating system requirements. This multi-device compatibility aligns with Pratama et al. (2023) assertion that adaptive e-modules must accommodate technological advancements and diverse learning environments. The user-friendly criteria also received an excellent rating because the materials and activities in the e-module can facilitate various student learning styles (i.e., visual, audio, kinesthetic). Visual learners benefit from the attractive design, clear fonts, and relevant images/illustrations that enhance material comprehension. Auditory learners are facilitated by engaging learning videos with clear narration and background audio that create an optimal learning atmosphere. Meanwhile, kinesthetic learners are supported through simple experiments and practical activities integrated into the science exploration sections. This comprehensive accommodation of varied learning styles is crucial for educational effectiveness, as demonstrated by Alyusfitri et al. (2024), whose research proves that interactive e-modules accommodating diverse learning styles can significantly improve concept comprehension and student learning outcomes.

The second aspect of e-module characteristic assessment, namely the JAS components in the e-module, is described in the main features of the e-module, which received an excellent rating. All JAS components, such as exploration, constructivist, science process, learning community, bioedutainment, and authentic assessment (Alimah & Marianti, 2016) are presented in the main features (Figure 3). The exploration, constructivist, science process, and learning community components are found in the e-module's main feature, "science exploration". “Science exploration” is a feature in the e-module containing various exploration activities related to the students' environment. Activities in “science exploration” are designed to vary according to the material to be studied; for example, in bacterial material, the “science exploration” conducted is a practicum observing bacteria using a microscope with samples that students can easily find in daily life, such as rotten fruits or vegetables and yogurt.

(a) (b) (c)

(d)

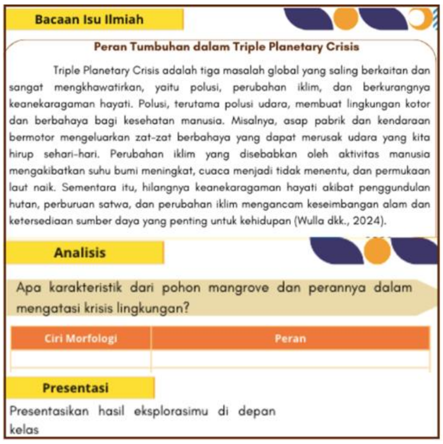


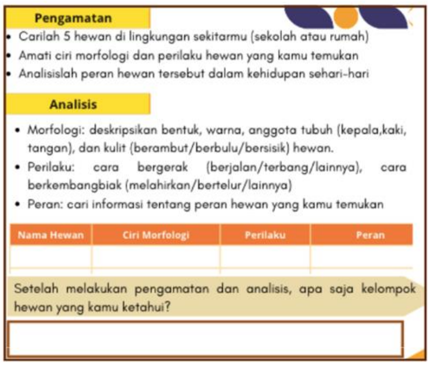
(e)

Figure 3. (a) Exploration, Constructivist, Science Process, and Learning Community, (b) Bioedutainment and Authentic Assessment after Learning, (c) Authentic Assessment before Learning, (d) Authentic Assessment during Learning, (e) Authentic Assessment after Learning

In "science exploration" activities, students are trained to be able to carry out science processes (i.e. observing, predicting, analyzing, and communicating exploration results), so they become accustomed to building a knowledge based on their exploration experience, thus this e-module has proven to meet the constructivist component characteristics of the JAS approach with excellent assessment results. "Science exploration" activities are also designed in groups to create a learning community and train cooperation and collaboration skills among students, thus providing opportunities for students to share information and knowledge with each other (Alimah & Marianti, 2016). The bioedutainment component (packaging learning to be more fun) is reflected in the e-module's main feature, namely "quiz time". "Quiz time" is a quiz feature found at the end of each material and is packaged in the form of interactive games utilizing the Wordwall application. Interactive games are presented in various ways aimed at making the learning process more interesting so that boredom can be minimized, strengthening material understanding, and increasing interactivity and learning motivation. In addition to quizzes, the e-module facilitates authentic assessment before, during, and after learning. Before learning, teachers can conduct oral questions and answers by utilizing the "did you know" and "science facts" features. During learning, teachers can use worksheets found in the "science exploration" feature, and at the end of learning, teachers can use practice questions found at the end of the e-module. Authentic assessment in education can help students understand science concepts and help teachers observe and assess student performance (Martatiyana & Faisal Madani, 2023).

The third aspect of e-module characteristic assessment, namely the inclusion of scientific literacy indicators in the e-module, is displayed in the main features consisting of content, process, and context aspects, receiving an excellent rating. The content consists of indicators for understanding scientific phenomena (Ning et al., 2020). The process consists of indicators for identifying and explaining scientific issues and using scientific evidence (Erniwati et al., 2020). The context consists of indicators for applying science concepts personally, socially, and globally (Ning et al., 2020). These scientific literacy indicators are reflected in the e-module material, "science facts" feature, and "science exploration" feature (Figure 4). The material in the e-module presents actual and contextual examples of natural phenomena. It contains “science exploration” activities that encourage students to observe and investigate scientific phenomena, such as in the binomial nomenclature naming system material, where the scientific names used are names of animals or plants that students often encounter in their surrounding environment. The “science exploration” feature also contains many activities that encourage students to analyze scientific issues relevant to daily life (e.g. analyzing plasmodium as a protozoan causing malaria and analyzing the role of plants in the triple planetary crisis).





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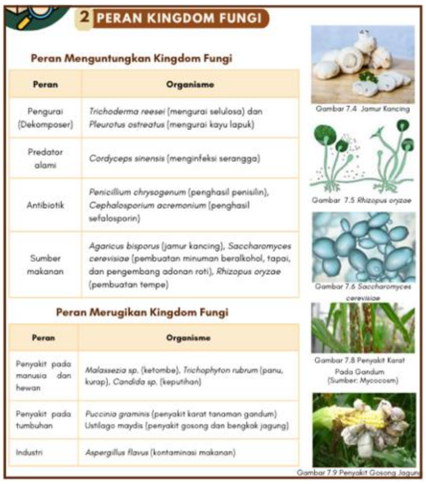

(c) (d)

Figure 4. (a) Indicators of Understanding Scientific Phenomena, Identifying and Explaining Scientific Issues, (b) Indicators of using Scientific Evidence, (d) Indicators of Applying Scientific Concepts Personally, Socially, and Globally

The indicators of scientific literacy using scientific evidence are reflected in the content or activities in the “science exploration” feature that help students design simple experiments, such as observing and classifying objects and living things around them. These simple experiments encourage students to search for, use, and analyze scientific evidence they obtain during the exploration process. In the “science facts” feature, there is also information about the use of science concepts in everyday life, such as the use of photosynthetic bacteria as a photosynthesis-boosting agent in agriculture and the working principle of animal echolocation, which inspires sonar technology. In addition, the indicator of applying science concepts personally, socially, and globally is also found in the material of each kingdom in the role of the kingdom in everyday life section. In the role section, there are several examples of organisms from that kingdom and their role in life. The last aspect of the e-module characteristic assessment, namely the reduction of misconceptions, is also displayed in the main feature (Figure 5) and gets an excellent score. This is indicated by the "did you know" and "science facts" features that explain concepts that often cause misconceptions, such as viruses and anything that only has some of the characteristics of living things is referred to as a non-living object.

Figure 5. Features that Explain Concepts are Prone to Misconceptions

The feasibility assessment of the e-module was also carried out to ensure that the developed e-module had met certain feasibility standards based on the criteria of the National Education Standards Agency in 2017 and helped improve the quality of the e-module through improvements to expert advice (Husnadi et al., 2024). Based on the assessment results, the JAS-based e-module received a very good feasibility score in terms of material aspects, material presentation, language, and graphics (Table 4). Feasibility in the material aspect received a very feasible score because the material presented was up-to-date, in accordance with the learning achievement indicators, did not cause misconceptions, and was relevant to everyday life. The accuracy and accuracy of the material presented can prevent students from experiencing misconceptions (Pratiwi et al., 2023). In the aspect of material presentation, it was also assessed as very feasible because the material was presented sequentially, easy to understand, and used illustrations that could clarify the content. The choice of sentences and spelling used in the e-module was also appropriate, straightforward, easy to understand, and according to the level of cognitive development of students, so that the e-module received very feasible criteria in the language aspect. E-modules that use good and correct language will make it easier for students to learn the material (Afriyanti et al., 2021). In the graphic aspect, the e-module meets very feasible criteria because it has an attractive design and uses a combination of fonts, colors, and sizes that are proportional and harmonious. In the end, the results of the expert assessment show that the developed JAS e-module has very good characteristics and feasibility for use in science learning on the material of classification of living things.

Table 4. E-Module Feasibility Assessment Results

Expert	Material	Presentation	Linguistic	Graphics	Total Score	Conclusion
E1	24	20	20	20	84	Excellent
E2	24	17	19	19	79	Excellent
E3	24	20	20	20	84	Excellent
E4	24	20	20	20	84	Excellent
Mean	24	19,25	19,75	19,75	82,75	Excellent

Before testing the effectiveness of the e-module in reducing misconceptions and strengthening scientific literacy, 29 students were involved in a readability test of the e-module because an e-module with good readability will make it easier for students to understand the material presented (Zakiyah &

Sudarmin, 2022). Based on the readability test analysis results, the average readability score in the aspects of design appearance, material, language, ease of use, and the JAS approach was 35.7 with very good criteria. Furthermore, as many as 32 students were involved who responded to the integrated scientific literacy and misconception instruments at the beginning (pre-test) and end (post-test) of learning that applied the JAS-based e-module. There were two research hypotheses (H_a) proposed, namely H_{a1} (There is a significant difference between pre-test and post-test scores in scientific literacy after the application of the JAS-based e-module) and H_{a2} (There is a significant difference between pre-test and post-test scores in misconceptions after the application of the JAS-based e-module). The prerequisite test results show that the data is normally distributed so that the paired t-test can be performed, and it can be concluded that both research hypotheses are accepted, which means that the JAS-based e-module is proven effective in reducing misconceptions while strengthening scientific literacy (Table 5).

Table 5. Summary of Data Analysis Results

Variable	Descriptive Statistic		Normality test		Paired t-test	
	Mean	SD	Statistic (df)	Sig	t (df)	Sig (2-tailed)
Scientific Literacy Pretest	16.13	5.961	.953 (32)	.180*	- 4.818 (31)	.000*
Scientific Literacy Posttest	22.44	6.395	.967 (32)	.420*		
Misconception Pretest	29.94	7.444	.959 (32)	.260*	4.636 (31)	.000*
Misconception Posttest	22.00	8.262	.988 (32)	.976*		

Note: *$p < 0.05$

In this study, a comprehensive discussion regarding students' scientific literacy was reviewed from the level of their conception, namely conceptual, functional, and nominal (Krisdiana et al., 2018). Students with conceptual scientific literacy acquire some key understandings of conceptual schemes from a discipline and can connect them to gain a general understanding of science, including procedural skills and understanding of scientific inquiry and the technological design process. Students with functional scientific literacy mean that they can explain concepts correctly but have limited understanding. Students with nominal scientific literacy can only recognize scientific concepts, but their level of understanding is lacking. In general, H_{a1} is accepted and is in line with the findings of Fonda et al. (2024) regarding the components of the JAS approach that are able to facilitate students' scientific literacy, or the findings of Setyowati et al. (2022) regarding the constructivist learning environment built through JAS can improve students' scientific literacy skills. However, there are some other important findings that are noted and there is still a need for continuous efforts to strengthen students' scientific literacy. The summary in Figure 6 and Table 6 shows that at the beginning of learning, as many as 71.1% of students had low scientific literacy (nominal), but after using the JAS-based e-module, the majority of students (24.6%) had high scientific literacy (conceptual). For the conceptual level of scientific literacy, all indicators experienced an increase with the highest increase in the indicator of explaining scientific issues (26.6%). This shows that students have had a deep scientific understanding because they have successfully mastered scientific concepts well and can connect various concepts from various scientific fields. They also understand information and are able to explain and make decisions based on data from various sources (e.g., text, diagrams, and tables).

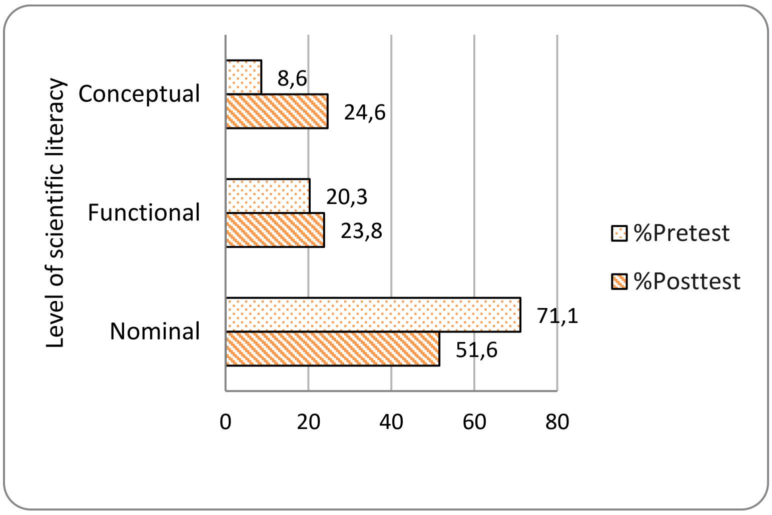

Figure 6. Scientific Literacy Level Results

The increase in conception at the conceptual level is certainly in line with a decrease (20.1%) at the nominal level. At this level, all indicators experienced a decrease with the largest decrease in the indicator of using scientific evidence (32.8%). Students in the nominal category still need to be given more in-depth guidance due to the limitations of their knowledge. They also still have a different understanding of the actual scientific concepts and are only familiar with scientific terms, but cannot provide explanations about these terms. In that category, it can also be ascertained that students have naive theories (Shofiyah, 2015), are not yet accustomed to solving problems by directly involving themselves, lack reading from various sources, and lack maximizing real learning experiences so that the concept of the material understood by students is not optimal. On the other hand, the increase in scientific literacy at the functional level also does not seem optimal (3.5%). However, all indicators also experienced an increase, where using scientific evidence (9.3%) became the indicator with the highest increase. At this level, it turns out that students are still confused in distinguishing between right and wrong (false positive and false negative), and are still having difficulty in understanding the interrelationships between information related to scientific terms.

Table 6. Results of Science Literacy Pretest and Posttest

Aspect	Indicators	Conceptual (%)			Functional (%)			Nominal (%)		
		Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
Content	1. Understanding scientific phenomena	31.3	34.4	3.1	28.1	34.4	6.3	40.6	31.3	-9.3
Process	2. Identify scientific issues	3.1	15.6	12.5	18.8	21.9	3.1	78.1	62.5	-15.6
	3. Explain scientific issues	0	26.6	26.6	23.4	28.1	4.7	71.9	50	-21.9
	4. Using scientific evidence	9.4	32.8	23.4	14.1	23.4	9.3	76.6	43.8	-32.8
Context	5. Apply scientific concepts personally, socially, and globally	7.8	14.1	6.3	15.6	20.3	4.7	76.6	65.6	-11

Regarding misconceptions, this study also categorized them based on the conceptions that students have, namely scientific conception (SC), false positive (FP), false negative (FN), misconception (MC), and lack of knowledge (LK) type 1, type 2, type 3, and type 4 (Istiyono et al., 2023). In general, H_{a2} is also accepted, but several interesting findings are found when in-depth analysis is carried out based on the conception (Figure 7). The most visible reduction in misconceptions is in the SC category, with an increase of 16.01%, and in the MC category (also called pure misconceptions), with a decrease of 4.69%, thus indicating the success of learning in building a correct understanding of concepts accompanied by strong confidence in students. Interesting findings are in the increase in FP (high confidence but flawed understanding) by 3.12% and FN (understanding the concept correctly but lacking confidence in the answer) by 0.4%. FP and FN conditions are included in misconceptions, but the FN condition is considered not dangerous because it is caused by student (Hestenes & Halloun, 1995). In addition to pure MC, a decrease also occurred in all types of LK (especially in type 4) which means that the JAS-based e-module is effective in reducing students' lack of understanding of the concepts learned, although it has not fully succeeded in overcoming previously formed misconceptions (especially type FP).

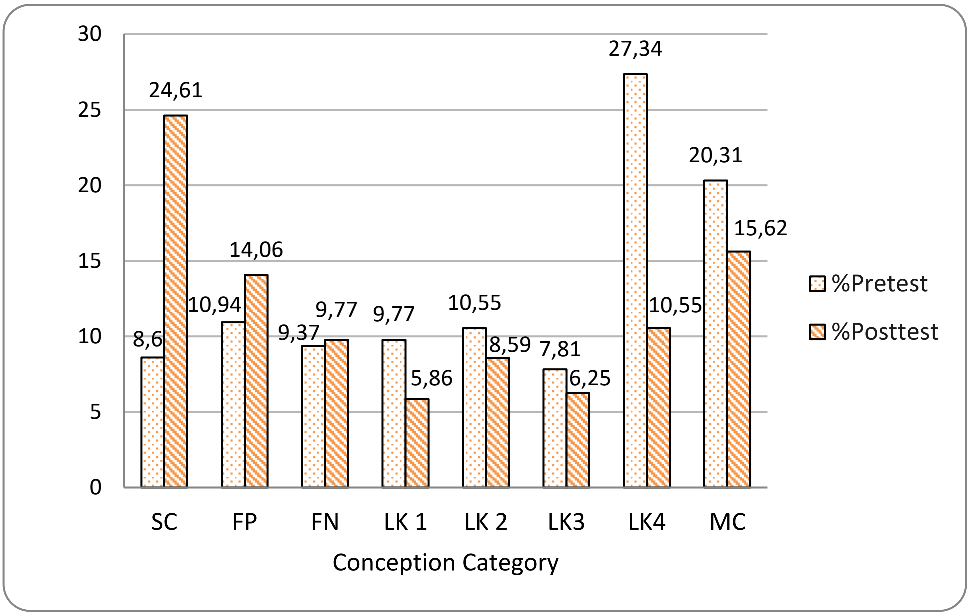

Figure 7. Conception Category Results

Figure 8 presents a more complete description of each learning achievement indicator. In the first indicator (distinguishing between living things and non-living things based on their characteristics) item number 1, misconceptions were identified for students who chose the option *pond* and *orchid* as living things in tier 1 and chose the option *because they can both breathe and photosynthesize* as the reason in tier 3. In this indicator, the majority of students have answered correctly in tier 1 (choosing the option *oyster mushroom* and *koi fish* as living things), but some students are still unable to give the right reasons about the characteristics of living things they have. In the second indicator (using the binomial nomenclature naming system) item number 2, the largest misconception (46.9%) occurred compared to other learning achievement indicators. In the question, most students believe that lowercase letters are used for writing binomial nomenclature with the genus and species names in tier 1 and tier 3. This misconception can occur because students still do not understand the procedures for writing scientific names properly.

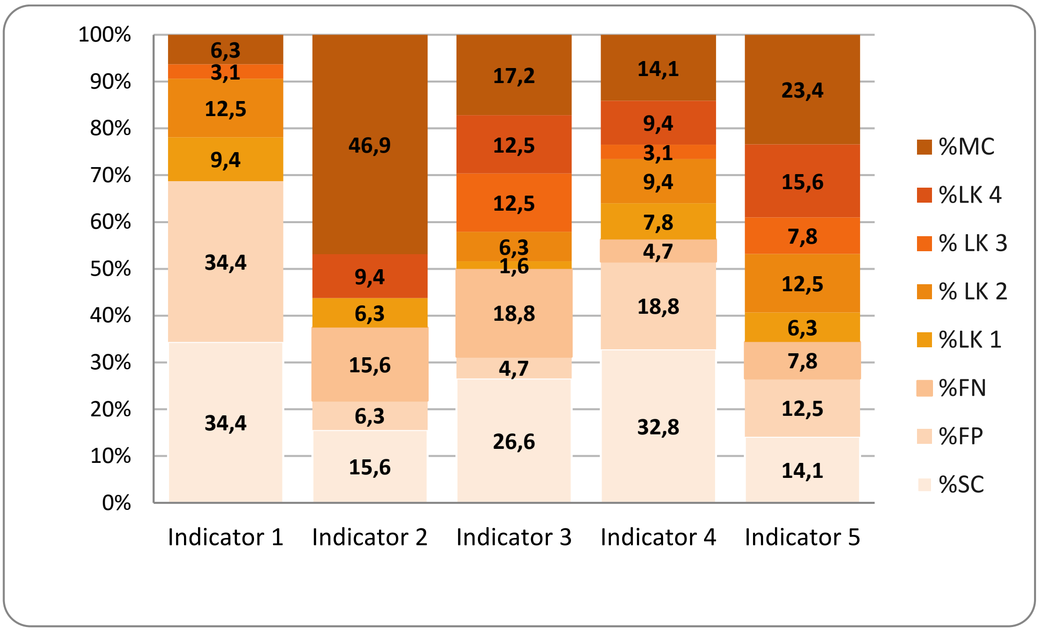

Figure 8. Posttest Results of Students' Conception Categories for Each Learning Outcome Indicator

The third indicator (analyzing the specific characteristics of each kingdom of living things) consists of two items, namely numbers 3 and 4 which refer to readings about scientific issues regarding climate change, the characteristics of archaebacteria found in permafrost, and the impact of climate change on bird migration. For question number 3, students have understood the general characteristics of bacteria as prokaryotic and unicellular organisms. However, their understanding of the characteristics of Archaebacteria, especially their ability to adapt to extreme environments, is still inadequate. This is seen from the majority of students who chose Eubacteria in tier 1 and there are still students who chose less appropriate reasons in tier 3. Although these options contain the keywords living in extreme temperatures, the complete statement is not in accordance with the characteristics of Archaebacteria. This indicates that students experience misconceptions and have not been able to distinguish correctly between Eubacteria and Archaebacteria. For question number 4, misconceptions occur when students choose the option bat as an animal that is in the same class as birds based on the characteristics in the reading in tier 1 and choose the option with the keyword can fly in tier 3. This shows that students experience misconceptions, namely understanding that bats belong to the aves group like birds because they have the ability to fly.

The fourth indicator (understanding and using a determination key to classify living things in the surrounding environment) consists of two items, namely number 5 (containing a reading about komodo dragons and a determination key for animalia), and number 6 (containing a reading about the exploration of organisms that contain characteristics and roles of several organisms and their determination keys). For question number 5, only 6.25% of students answered incorrectly in tier 1 (determining the appropriate determination key for komodo dragons), so it can be said that most students already know how to use a determination key to classify organisms; while in tier 3, some students are still confused in choosing reasons, where they choose the option komodo dragons are wild animals like reptiles in general. This shows the continued existence of misconceptions among students, namely understanding reptiles as a group of wild animals.

For question number 6, misconceptions occur when students use the determination key to classify organisms. The most dominant misconception is seen in the selection of the algae option in tier 1 and the use of the protist kingdom determination key in tier 3, which indicates that students are still having difficulty identifying the specific characteristics of each kingdom. This classification error can be caused by students' limited understanding of analyzing the characteristics of organisms contained in scientific readings and the inability to use the determination key appropriately. This shows that students have not been able to analyze the characteristics of organisms correctly and have difficulty in using the determination key to classify organisms into the appropriate kingdom. This finding is reinforced by the research results of Gultom (2023) which shows that students experience misconceptions in the material of the determination key because of the complex concepts and students' lack of understanding of the rules of the determination key, especially in the comparison of morphological characteristics of organisms.

The last indicator (explaining the role of living things in everyday life) consists of question number 7 (containing a reading about the benefits of Rhizopus sp. and factors that influence tempeh fermentation) and question number 8 (containing a reading about the characteristics of plants for greening urban city buildings). For question number 7, misconceptions occur because in tier 1 and tier 3, students assume that the nutritional content of tempeh is lower if it is fermented at a higher temperature. They argue that high temperatures can accelerate the growth of mold, so fermentation is not perfect. This misconception indicates that students have not fully understood the concept of temperature influence in fermentation. They have not been able to analyze the information in the reading in-depth, thus making incorrect generalizations. This can happen because students have difficulty connecting information in the reading with the knowledge they have previously possessed.

For question number 8, the majority of students have well understood the role of plants in greening vertical urban buildings, as seen by 21 students who chose high photosynthetic ability in tier 1 and 19 students who understood the ability of plants to convert CO_2 into O_2 and absorb pollutants in tier 3. However, there are still misconceptions in some students who chose the option of ease of care and cost in tier 1 and adaptability in tier 3. This misconception indicates that some students still tend to view the success of vertical greening from a practical and economic aspect, not from its ecological function in improving urban air quality. This error in understanding reflects that students have not fully understood the main concept of vertical greening, which emphasizes the ability of plants to carry out photosynthesis and reduce pollutants as a solution to environmental problems in urban areas.

The final stage, namely dissemination, was carried out through limited socialization by presenting the research results of the JAS-based e-module development to science teachers and students at MTs Ishthifaiyah Nahdliyah. Overall, the results demonstrate that the developed JAS-based e-module on the classification of living things is effective in strengthening scientific literacy and reducing student misconceptions. This effectiveness aligns with Satuti & Atmojo (2025), who demonstrated that student misconceptions can be minimized through contextual strategies and engaging visual media. Our findings are further corroborated by multiple studies showing that e-modules significantly improve students' scientific literacy skills, including interactive e-modules (Ismaniati & Iskhamdhanah, 2023), STEM-based e-modules (Hutomo et al., 2022), and SETS-based e-modules (Nisa et al., 2022). These findings support the argument that integrating active learning approaches, such as those facilitated by the JAS-based e-module, plays a crucial role in enhancing students' scientific understanding and literacy.

However, the JAS-based e-module has not been able to fully reduce all misconception types, particularly FP and FN type misconceptions. This limitation reflects the inherent resistance of misconceptions to change, as highlighted by Gurel et al. (2015), who emphasized that even explicit corrective instruction may not fully eliminate deeply rooted misconceptions. The persistence of FP-type misconceptions in our study aligns with (Melta et al., 2023), who found that inadequate focus during learning processes can lead to imperfect reasoning and incorrect conclusions. Furthermore, Gultom

(2023) reinforced that misconceptions occur when students struggle to organize and apply concepts effectively. Our observations indicate that misconceptions arise when students partially absorb information without fully grasping contextual relationships between concepts. Collectively, these findings suggest that while the JAS-based e-module shows significant promise in misconception reduction, certain misconception types require additional intervention strategies beyond environmental exploration approaches.

CONCLUSION

Based on the research findings, the developed JAS-based e-module demonstrates very good characteristics and feasibility. Furthermore, it has been proven effective in strengthening scientific literacy and reducing student misconceptions regarding the classification of living things. For optimal impact, JAS-based e-modules should be supported by more intensive learning strategies to overcome student misconceptions for maximum results, ensuring a comprehensive approach to addressing learning difficulties. It is also recommended that academics conduct further research to explore its application across other science topics or educational levels.

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