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Analysis of Science Literacy Profile and Development of E-Book Interactive Learning Media for Junior High School Students on Earth Structure Material

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Abstract

This study aims to evaluate students' science literacy profile and implement earth structure and disaster mitigation materials to improve junior high school students' science literacy. This research uses a type of introductory research that applies analysis techniques in the form of descriptive research design (DPD). The research instruments used include science literacy tests, student learning experience questionnaires, and teacher performance observations in delivering the material. This indicates that the science literacy skills of junior high school students can be further improved by using appropriate learning. Based on the results of the research obtained, the science literacy indicator 'Designing Scientific Investigations' received the highest score with an average of 3.275, while 'Critically Evaluating Scientific Information' received the lowest score of 3.206. Based on the results of the research data that has been obtained, it is concluded that students' science literacy skills still need to be improved. However, female students tend to have better science literacy skills than male students, which indicates a challenge in achieving science literacy skills at an adequate level. The indicator with the lowest level of science literacy was critically evaluate scientific information. Therefore, the study recommends the development of contextualized inquiry-based learning media and technology integration to support more effective learning, as well as training for teachers to facilitate learning that trains students' critical thinking skills.

Keywords: physics education, reflective thinking skills, earth physics syllabus, earth physics lecture, science literacy

INTRODUCTION

Education is important because it provides the initial skills needed to improve and compete in an ever-evolving world. 21st-century education faces diverse challenges in shaping a knowledgeable and strong character generation (Hidayat, 2021; Jaya et al., 2023; Mardhiyah et al., 2021). In this context, character education becomes one of the main focuses in shaping individuals who have integrity, responsibility, and empathy (Lubis et al., 2023; Mardhiyah et al., 2021; Anita, 2020). One effective

way to integrate character education is by developing learning tools that explicitly contain character values. In addition, in modern education, teachers must develop learning methods that are contextual, innovative, creative, collaborative, and responsive. Not a few teachers have difficulty adapting to the learning needed by students (Irsan, 2021).

In 2022 research states that science literacy is one of the answers in realizing various problems in the 21st century (Pare & Sihotang, 2023; Umayah & Riwanto, 2020). This is supported by the statement of the Ministry of Education and Culture that literacy is the ability to read, understand, and manage information properly and correctly, with global developments that have placed information and data capabilities as important and influential factors in everyday life. This definition is in line with the Law of the Republic of Indonesia No. 3/2017 on the book system, which defines literacy as the ability to receive, understand, and manage information properly.

Based on the analysis conducted on 20 researches related to the science literacy profile data displayed, there are various categories of science literacy assessment of students at the junior and senior high school levels, namely low to high categories. Based on the results of the data analysis, test results were obtained in the high and medium categories. However, there are still students with abilities classified in the low category in some areas, so the distribution of research related to the profile of science literacy has not been maximized (Isnaeni & Sa'diyah, 2024; Istiqomah & Hariyono, 2019). Low scientific literacy among students leads to difficulties in understanding and applying scientific concepts in everyday life (Boma et al., 2024; Sharon, 2020).

In science learning, science literacy is crucial for students to produce a qualified and competent generation to compete internationally. Science literacy also enables students to understand natural phenomena, identify scientific questions, and draw conclusions based on data that has been obtained. (Amiruddin et al., 2022; Deta et al., 2023; Muizz & Prahani, 2023). Science learning has great potential to develop students' basic literacy. Basic literacy includes the ability to read and write as well as the ability to think critically, solve problems, and communicate effectively. However, to achieve these goals, appropriate learning media is needed. One of the learning media that can be used is E-book Media (Sunarti et al., 2023; Sari et al., 2022; Yanti & Fauzi, 2021; Firdausy et al., 2020; Kusumawati et al., 2020).

Indonesia is located on the Ring of Fire because Indonesia is surrounded by three plates, namely the Indonesia-Australia plate, the Eurasian plate, and the Pacific plate, which merge and surround the Indonesian archipelago. Therefore, Indonesia is a country that is often hit by natural disasters such as earthquakes, volcanic eruptions and tsunamis. These plates will continue to slide, collide, and move in all directions so that the movement forms a very deep sea trough (Hariyono & Liliasari, 2018; Suprapto et al., 2022). Therefore, the Indonesian archipelago is located in a relatively high earthquake activity region. At the Junior High School (SMP) level and equivalent, understanding the earth's structure and disaster mitigation are important and interesting topics to learn. The earth's structure includes complex and diverse layers, while disaster mitigation involves measures to reduce the impact of unexpected natural events. Thus, understanding both the structure of the earth and the importance of disaster mitigation to learners is an important and educational lesson to learn.

In the modern era, science literacy is an important competency for students to understand natural phenomena and make decisions based on scientific evidence (Manderino & Castek, 2020). One of the relevant topics in science education is the structure of the earth, which is closely related to understanding the mitigation of natural disasters such as earthquakes, volcanic eruptions, and landslides (Puspitasari, 2024). Despite its importance, various studies show that students' level of science literacy, particularly on earth structure, is still low. This is exacerbated by the lack of interesting and contextualized learning media to support students' understanding.

This research aims to evaluate students' science literacy profile by implementing earth structure and disaster mitigation materials to develop students' science literacy skills based on the completeness of knowledge achievement and student responses. By profiling students, this research is expected to provide an in-depth picture of students' initial abilities related to science literacy skills on earth structure and disaster mitigation materials. In addition, this research also aims to examine the role of E-book media as one of the innovative solutions in developing learning media to improve students' science literacy, especially in the context of science learning on earth structure and disaster mitigation materials.

METHODS

This study uses the PISA framework to analyze the physics science literacy skills of grade VIII junior high school students in Surabaya. This research method uses a type of analysis technique in the form of descriptive analysis research design (DPD). The results of this study are intended as a rationale for improving the model and innovation of learning media in schools, with a focus on improving the quality of science literacy competencies of junior high school students based on PISA (Dian et al., 2023; Rahma & Agustin, 2021). Therefore, the information obtained from this research is very useful for schools and is the basis for improving and improving the quality of learning in the school environment.

This research took subjects from grade VIII junior high school students in Surabaya, with 102 students as participants. The research instruments include a knowledge and skills test in science literacy and a learner response questionnaire. The questionnaire consists of five questions to students regarding their learning experience and teacher performance in teaching science learning in the classroom. The interview questions were listed on the last sheet of the student interview questionnaire, making it possible to interview students in writing to save time. in addition, the results of interviews with teachers were conducted orally. Test questions, surveys, and student interview activities were carried out after the data collection in the classroom, and the interview with the subject teacher was conducted at the end of the research implementation time.

The purpose of this interview is to explore further information related to the atmosphere of learning activities in the classroom, to find out the implementation of students' science literacy activities, and students' interest in using learning media, namely E-Books as the learning media offered. To get more in-depth information about students' science literacy skills at the junior high school level. This study followed the research stages described in FIGURE 1, including data collection through tests, interviews, questionnaires, and data analysis using a qualitative descriptive approach.

FIGURE 1. Steps in the research

This study used a descriptive method to analyze the initial profile of junior high school students' science literacy skills on earth structure material. The research sample consisted of students selected by purposive sampling based on class representation and school background. Data were collected through a science literacy test of 5 essay questions designed to measure three main aspects of science literacy: scientific competence, content, and context. The test instrument was validated through two stages: expert validation by science education experts to ensure content conformity with the science literacy framework based on PISA and field trials to assess the reliability and clarity of the instrument. Data analysis was conducted by calculating the average score on each science literacy indicator, followed by in-depth interpretation to identify students' strengths and weaknesses. This research design aims to provide a comprehensive picture of students' initial abilities while informing the development of more relevant learning media.

A test consisting of 5 description questions was given to analyze the profile of students' science literacy skills. Based on the PISA 2025 framework, there are several main indicators used to measure students' science literacy, including Science Content Knowledge, which consists of Understanding key concepts in science such as physics, chemistry, biology, and earth science, Mastery of theories, laws, and models of science, and Knowledge of scientific facts and explanations of natural phenomena. Furthermore, the second main indicator, Procedural Knowledge, consists of the ability to apply scientific reasoning and thinking, skills in designing and conducting scientific investigations, the ability to analyze data and draw conclusions, and skills to interpret evidence and make conclusions (Indana et al., 2022a; Rosmiati & Satriawan, 2022). However, the researcher developed the question exercises by including indicators of Explaining phenomena scientifically, interpreting scientific data and evidence, critically evaluating scientific information, designing scientific investigations, and using scientific information for decision making.

This introduction study has limitations because carried out with a limited sample to be followed by expanding the population. Hence, it is recommended that further investigations be conducted with a more research design to support the results of this study. This study involved administering a science literacy test for students, which consisted of 5 essay questions that underwent a validation process. The test instrument was designed to measure three main aspects of science literacy: scientific competence, context and content, which were selected based on the PISA framework to ensure alignment with international benchmarks. The validation process was conducted through expert testing and limited trials to ensure the content validity and reliability of the instrument. This study aims to analyze the initial profile of students' science literacy on earth structure material and develop learning media that support the improvement of these abilities.

TABLE 1. Validity Instrument Result

Question Number	r_{table}	r_{count}	Sig. (2-tailed)
1		0.598	0.000
2		0.659	0.000
3	0.1622	0.594	0.000
4		0.652	0.000
5		0.656	0.000

The instrument validity results listed in TABLE 1 illustrate that the r_{count} of each item is more significant than r_{table}, thus indicating the validity of the instrument. In addition, the significance value of each question item is also less than 0.05, supporting the conclusion that all questions are valid.

TABLE 2. Students' science literacy ability category

Literacy Level	Category
30-39	Very Low
40-55	Low
56-65	Medium
66-79	High
80-100	Very High

The data obtained from the students' science literacy test results were analyzed based on the indicators of science literacy competencies according to the PISA framework that had been tested.

RESULTS AND DISCUSSION

The results of this research will discuss measuring science literacy skills in science learning at the junior high school level, as well as the potential implications of e-books on Science learning at the junior high school level. This study aims to determine and describe the science literacy profile of junior high school students based on PISA indicators, which can be analyzed from student responses, as well as the completeness of knowledge achievement. By profiling students, this research is expected to provide an in-depth picture of the initial ability of science literacy on earth structure material and disaster mitigation.

Learners were given an essay test covering the five main indicators of Science Literacy. Each learner is expected to be able to understand the indicators of Explaining phenomena scientifically, Interpreting data and evidence scientifically, Critically evaluating scientific information, Designing scientific investigations, and using scientific information for decision making. FIGURE 2 presents comprehensive results on the level of science literacy skills achieved by learners.

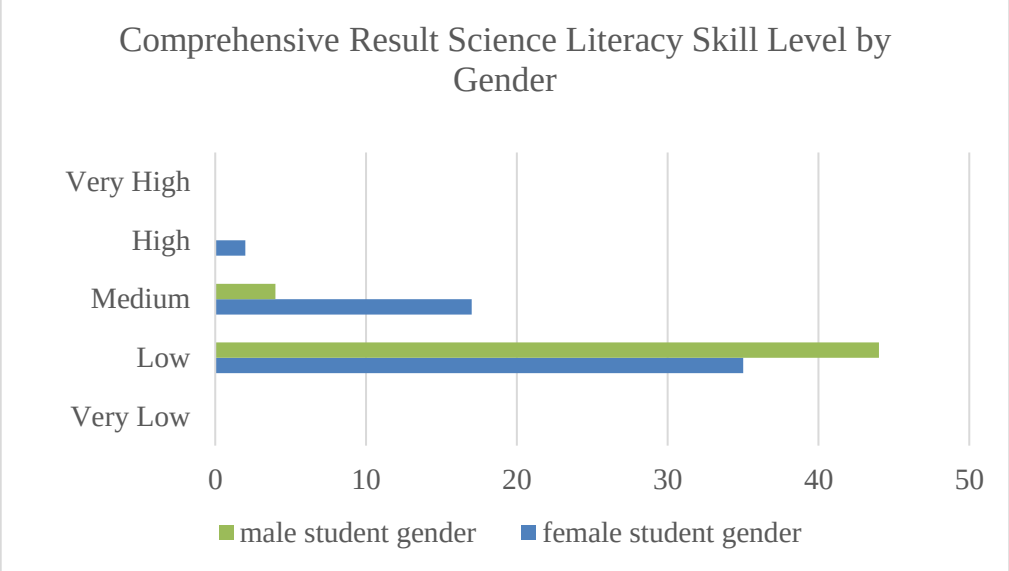

FIGURE 2. Science Literacy skill results

Based on FIGURE 2, the results of the science literacy test of junior high school students show that most students are in the low category, especially in the group with scores below 55; this indicates a low level of science literacy skills. This finding is in line with previous research, which states that the science literacy skills of female and male students are still low. In the moderate category, if reviewed based on the results in FIGURE 2, the number of students with female gender is more than that of male gender. However, this number is still relatively low, and female students tend to have better science literacy skills than male students, indicating a challenge to achieve science literacy skills at an adequate level (Indana et al., 2022b; Rosmiati & Satriawan, 2022).

FIGURE 2 also shows that out of 79 learners in low categories, there were 35 female and 44 male students. In the medium category, there were 21 learners, with 17 female students and four male students. Moreover, only two female students reached the high category. Thus, the overall level of science literacy skills is low, and female students show slightly higher skills than male students. This analysis provides a basis for developing more effective learning strategies to develop junior high school students' science literacy skills.

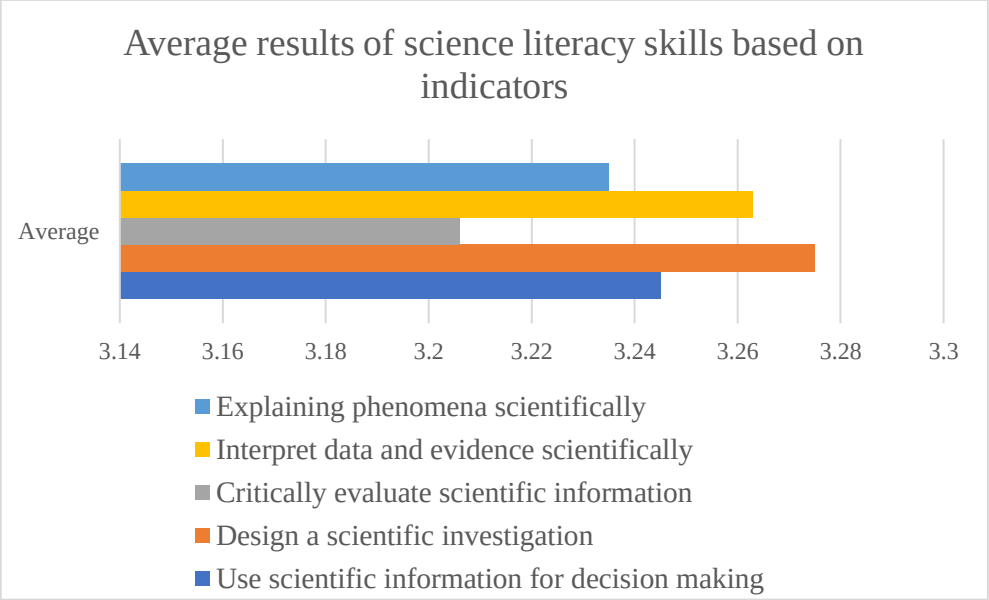

FIGURE 3. Average results of science literacy skills based on indicators

Courtesy of FIGURE 3, the average results of junior high school students' science literacy skills test on five indicators obtained by students are obtained. It is known that there is a significant difference based on the average score of each category science literacy skills. The highest score for science literacy skills was obtained in the indicator "Designing a scientific investigation," with an average score of 3.275. Meanwhile, in the category "critically evaluate scientific information," obtained the lowest score with average of 3.206. These differences indicate strengths and weaknesses in students' science literacy competencies. The high score on the indicator ‘Designing scientific investigations’ could be due to the emphasis in the curriculum on experimental processes and scientific procedures, which are often a major part of science learning in the classroom. However, the low score on the indicator ‘Critically evaluate scientific information’ may reflect the lack of emphasis on analytical skills in evaluating the validity and credibility of scientific information. This suggests an urgent need to integrate more inquiry-based learning methods and critical reasoning into science teaching. These findings are in line with previous research with the aim of the study, which was to identify the initial profile of students' science literacy skills to find areas that require strengthening. With these results, the study recommends the development of inquiry-based learning media capable of encouraging students to not only understand scientific concepts but also actively evaluate and critically examine information (Komalasari et al., 2019; Pratiwi et al., 2021; Rosita, 2023).

Students often face difficulties and lack confidence when critically evaluating scientific information in science literacy. Therefore, teacher strategies are needed to improve students ' science literacy skills, especially in this area. Based on the results of previous research, indicators in explaining scientific phenomena are superior to indicators evaluating information because students find it easier to remember and recognize scientific phenomena. Although students may have more opportunities to deepen understanding by recalling and recognizing scientific phenomena about science problems, the ability to evaluate information in learners during learning may have needed to be strengthened. Therefore, it needs to be strengthened through exercises and learning content that aim to improve students' science literacy skills in evaluating, such as summarizing and reflecting on the material that has been learned.

Learning methods that encourage self-reflection and group discussions help students develop the science literacy skills they need to evaluate their answers. Good feedback helps students understand the mistakes they may have made and provides clear instructions for improvement. Therefore, such improvements can positively contribute to students' science literacy skills and improve their scientific evaluation of phenomena. To achieve success in improving science literacy, it is necessary not only to remember and understand based on phenomena but also the ability of students to integrate all the information and concepts to improve students' science literacy.

Students' answer to each question reflect their level of science literacy related to the given problem. However, not all students can provide comprehensive answers using the appropriate science literacy indicators. Some students may choose to answer with answers that do not match the given indicators, thus affecting their overall level of science literacy. Therefore, special attention from science teachers to students' science literacy skills is essential. This includes providing focused practice and feedback to develop students' science literacy skills.

This approach can be implemented through various learning strategies encouraging students to think critically to improve their science literacy. Providing constructive feedback to students is also very important in helping them gradually improve their science literacy skills. The following are examples of student answers with indicators of science literacy skills.

TABLE 3. Science literacy test results question 1

Science literacy skill indicators	**Question 1**	**Students' answers to the correct and complete science literacy exercises**
Explaining phenomena scientifically	Explain how the structure of the earth's layers, such as the crust, mantle, outer core and inner core, affects the occurrence of geological phenomena such as earthquakes and volcanic eruptions?	The earth's structure consists of the crust, mantle and core. Earthquakes occur due to the movement of plates in the earth's crust. If there is great pressure, the plates can break, causing an earthquake. Volcanic eruptions are also from the mantle as magma rises to the surface through the crust.

Based on TABLE 3 shows that the questions are tested to junior high school students to measure the ability of students to understand the basic concepts of geoscience phenomena based on the structure of the earth. this is in accordance with science literacy indicators related to understanding science phenomena. students are expected to be able to develop a science literacy profile by describing the various structures that make up the earth's layers.

TABLE 4. Science literacy test results question 2

<table>
<tr><th>Science literacy skill indicators</th><th>Question 2</th><th>Students' answers to the correct and complete science literacy exercises</th></tr>
<tr><td>Interpret data and evidence scientifically.</td><td>Based on the following seismic data:
<table><tr><td>Seismic Station</td><td>P Wave Arrival Time (seconds)</td><td>S-wave Arrival Time (seconds)</td><td>Time Difference (seconds)</td></tr><tr><td>Station 1</td><td>10</td><td>18</td><td>8</td></tr><tr><td>Station 2</td><td>12</td><td>22</td><td>10</td></tr><tr><td>Station 3</td><td>15</td><td>28</td><td>13</td></tr><tr><td>Station 4</td><td>20</td><td>38</td><td>18</td></tr></table>Analyze the differences in wave travel times in different layers of the earth to determine the location of the earthquake epicenter!</td><td>From the table, the P-wave is faster than the S-wave, so the epicenter is close to station 1. The S-wave arrives late at other stations, probably because they are further away from the earthquake.</td></tr>
</table>

Based on TABLE 4, it shows questions and answers designed to test students' science literacy skills, especially on the indicator of Interpreting data and evidence scientifically. the questions tested to students are related to using a data table of P and S wave arrival times from four seismic stations to determine the location of the epicenter of an earthquake. The question was tested to students to encourage students to understand the difference in P and S wave velocities, relate the time difference data to the epicenter distance from the stations, and make logical interpretations. the advantage of one of the students' answers is that based on the data that has been conveyed in the questionnaire that students provide answers by showing that participants understand the relationship between wave arrival time and epicenter distance and participants can conclude that the epicenter is closer to station 1 based on wave arrival time. However, learners' answers do not mention the complete process of determining the epicenter, such as how the time difference is used to calculate the epicenter distance quantitatively.

TABLE 5. Science literacy test results question 3

Science literacy skill indicators	Question 3	Students' answers to the correct and complete science literacy exercises
Critically evaluate scientific information.	Several news sources state that earthquake disaster mitigation in Indonesia is less effective. Critically evaluate what are the main factors that affect the effectiveness of earthquake disaster mitigation in Indonesia, in terms of policy, technology and public education?	Earthquake mitigation is less effective due to the lack of evacuation drills for the public. Also, the technology is sometimes unevenly distributed throughout the region. The government should educate people more about how to save themselves during an earthquake.

Based on TABLE 5, the questions tested to learners aim to measure learners ability to analyze claims from various sources and relate them to relevant scientific facts. one of the learners answers illustrates that learners can Identify important factors that affect mitigation: public education, technology equalization, and evacuation drills. however, learners do not include data-based evaluations or specific examples such as the lack of earthquake sensors in remote areas or the success of mitigation in certain areas.

TABLE 6. Science literacy test results question 4

Science literacy skill indicators	Question 4	Students' answers to the correct and complete science literacy exercises
Design a scientific investigation.	If you want to investigate the relationship between the distribution patterns of plate tectonics and the location of earthquakes in Indonesia, design a scientific investigation complete with objectives, research steps, and necessary tools?	I will research earthquake patterns in Indonesia. How: 1. Find earthquake data from BMKG for 10 years. 2. Make a map of the earthquake locations. 3. Compare with the plate tectonics map. Tools: computer, map, and BMKG data.

Based on TABLE 6, the questions tested to learners aim to measure learners ability to design research relevant to science problems. based on learners answers, it illustrates that learners have clear objectives in knowing the relationship between plate distribution and earthquake locations and mention relevant research steps, such as using data from BMKG and plate tectonic maps. however, learners do not include details of the analysis method for example, how earthquake data will be processed or analyzed, and do not include variable control or in-depth investigation.

TABLE 7. Science literacy test results question 5

Science literacy skill indicators	Question 5	Students' answers to the correct and complete science literacy exercises
Use scientific information for decision-making	A region in Indonesia experiences frequent earthquakes. As a scientist, what information would you use to recommend mitigation measures to the local government? Explain which measures you prioritize and why!	I would suggest building earthquake-resistant buildings and preparing evacuation routes. The reason is that this helps to reduce casualties during a major earthquake. In addition, people need to be given training in dealing with earthquakes.

Based on TABLE 7, the questions tested to learners aim to measure learners' ability to use scientific knowledge in designing relevant solutions. Based on learners answers, it illustrates that learners have provide concrete mitigation measures, such as earthquake-resistant buildings and evacuation routes and pay attention to community education aspects. however, learners do not utilize scientific information or specific data to support recommendations and do not consider priorities based on risk levels or regional needs.

The results of interviews with teachers and students regarding the use of e-books as learning media on earth structure and disaster mitigation materials show that e-books are considered an innovation that attracts students' reading interest. Teachers assess that e-books are able to present rich visualisations, such as interactive illustrations and diagrams, making it easier for students to understand abstract concepts in this material. In addition, interactive features, such as links to educational videos and online quizzes, provide a more dynamic learning experience than conventional textbooks. The teacher revealed that physics e-book learning media allows the delivery of more in-depth material with visualisation of abstract concepts and By applying appropriate methods and utilising technology, students' science literacy skills are expected to be improved effectively. as is the case with earth structure and disaster mitigation material, so that students can understand the principle more clearly. On the other hand, students stated that the accessibility of the e-book allows them to study at any time and repeat poorly understood parts, which supports independent learning. However, the optimisation of this media requires teacher assistance, especially to help students connect the concepts learned with their application in daily life. Students also revealed that the digital format makes the material more accessible at any time through their devices, thus increasing their learning convenience and motivating them to explore the topic more deeply. However, some students mentioned that teacher guidance is still needed to understand more complex parts of the material. Overall, e-books are considered effective in supporting innovative and relevant learning with technological development.

CONCLUSION

Based on the results of the research that has been conducted, students' science literacy skills still need to be improved. The indicator with the lowest level of science literacy was ‘critically evaluate scientific information’, while the indicator with the highest score was ‘design scientific investigations’. This indicates that the science literacy skills of junior high school students need to be improved by conducting science literacy exercises by educators. This indicates that the science literacy skills of junior secondary school students are expected to be further improved by practicing science literacy exercises by educators. Findings from surveys and tests with science literacy indicators show that this ability can be improved with appropriate learning. The results also found that the use of media and technology in learning in schools still needs to be maximized. This study's results indicate the importance of developing innovative learning models in line with technological developments, especially in science learning. This is supported by the results of interviews with teachers and students regarding the use of physics e-book media which show that this media has great potential in improving mastery of physics concepts, especially through interactive features such as simulations, animations, and links to virtual experiments. The combination of using e-books with interactive discussions in class proved to be an effective approach to strengthening mastery of physics material. So from this,

researchers hope for further research to continue and deepen research related to developing science literacy e-book media, especially earth structure material and disaster mitigation for junior high school students.

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