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Improvement of Students' Literacies Skills in The Knowledge Aspect through Science, technology, engineering, and mathematics (STEM)-Integrated Module

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ABSTRACT

The 21st century requires students to have abilities and competencies that are by the times. These abilities and competencies include Critical Thinking, Creativity, Communication Skills, and Collaboration. This study aims to examine the improvement of Science, technology, engineering, and mathematics (STEM) literacy in aspects of knowledge after applied learning using STEM-based modules. The research method is quasi-experimental with a pretest-posttest one group. The population of this study is class X high school students in one of the high schools in Karawang, Indonesia. The institution used a multiple-choice question of 25 questions consisting of 12 questions to measure scientific literacy, 6 questions to measure mathematical literacy, and 7 questions to measure technological engineering literacy. The increase in STEM literacy is seen from the normalization gain (n-gain) analysis. STEM literacy ability has increased by looking at the results in gain <g> obtained by 0.69 in the medium category. The increase in STEM literacy in the knowledge aspect of science literacy results in gain <g> obtained by 0.66 in the medium category, the n-gain basic mathematical literacy obtained by 0.71 in the high category, and the technology-engineering n-gain literacy obtained by 0.73 in the high category. this shows that learning by using STEM-based modules can improve STEM literacy skills in alternative energy materials.

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1. INTRODUCTION

The 21st century requires students to have abilities and competencies that are by the times (Pablo *et al*., 2022). 21st Century Skills abilities and competencies include Critical Thinking, Creativity, Communication Skills, and Collaboration (Tohani & Aulia, 2022). Education is faced with several challenges, including that education should produce human resources who have the skills to be ready to compete in the era of globalization.

Based on this, physics learning at this time needs to be prepared to produce students who can compete in the era of globalization. Integrating science with other fields of learning has been carried out by several developed countries, namely by developing Science, technology, engineering, and mathematics (STEM) education. STEM education can support critical thinking skills that will make learners solve problems creatively so that they are beneficial to their world of work (Hacioğlu & Gülhan, 2021; Baharin *et al*., 2018; Retnowati & Subanti, 2020). STEM learning will indirectly require learners to think critically in solving problems and be able to find the right solutions according to the problems they face.

the purpose of STEM education is for learners to be able to apply the basic content and practice of STEM disciplines in life situations to develop STEM-literate learners. Research on implementing learning aimed at building STEM literacy has not been widely carried out in Indonesia and in countries that have implemented STEM education. Some research on STEM literacy is still in the form of a study of learning methods or processes that can build STEM literacy. The influence of project-based learning with a STEM approach on the STEM literacy of junior high school students. In this study, it was found that PjBL-STEM learning has a strong influence on improving each component of STEM literacy.

A preliminary study was conducted on high school physics teachers in Karawang to see an overview of the physics learning process in schools. The results of the preliminary study include:

(i) Physics learning has implemented an independent curriculum centered on students, but the learning carried out has not invited students to solve problems and design solutions to these problems. Students are directed to make projects without being given a problem first;
(ii) Students' knowledge of STEM is still low, because physics learning does not integrate between disciplines, and only focuses on physics content;
(iii) The integration of technology in learning is limited to the use of media such as LCD projectors. Thus, students' knowledge of simple technology related to the material that has been taught is still low.

The results of the preliminary study provide information that learning that occurs in schools at this time has not led to the formation of STEM literacy or has not facilitated students to master 21st-century skills.

Integrated STEM education is an interdisciplinary approach to learning, in which students use science, technology, engineering, and mathematics in a real context that connects schools, the world of work, and the global world, thus developing STEM literacy that enables students to compete in the new economic era. The goal of STEM education for all learners is to apply and practice the basic content of STEM to the situations they face/encounter in life, becoming STEM literacy'. In STEM literacy, 3 components are trained, namely; Science literacy, mathematical literacy, and technology-engineering literacy (Tang & Williams, 2019).

The definition of science literacy according to PISA 2015 is the ability of a person to use his knowledge of science to identify questions, acquire knowledge, explain scientific phenomena and draw conclusions based on evidence around science-related issues, understand the

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features of science that shape knowledge and research, concern about how science and technology shape material, intellectual, environmental culture, and willingness to engage in the study of issues science, as reflective citizens.

Technological literacy is the ability to understand how technology is created and how technology shapes society or how technology is shaped by society, while engineering literacy is the ability to apply science and mathematical principles in the practice of designing, creating and operating a process or system.

Mathematical literacy can help someone recognize the role of mathematics in the real world so that it can be taken into consideration to make a decision (Stacey, 2011). Mathematical literacy is an individual's ability to formulate, use, and interpret mathematics in a variety of contexts including reasoning and using mathematical concepts and procedures to explain and estimate phenomena.

Based on the definition of each component of STEM literacy, it can be concluded that achieving a goal requires knowledge and understanding in each field and applying these knowledge, therapies, and abilities. Not only are the components separated, but STEM literacy has a strong relationship between each component.

2. METHODS

This study was a quasi-experimental study with a one-group pretest and posttest (Creswell, 18). The population in this study was one of the high schools in Karawang, Indonesia, with a sample of 36 grade X students. There were 23 female students and 13 male students. The Maatery taught is alternative energy. Data collection is carried out by tests. The instrument to measure students' STEM literacy skills in the aspect of knowledge with 25 multiple-choice questions consists of 12 questions measuring science literacy, 6 questions measuring mathematical literacy, and 7 questions measuring technological and engineering literacy. The instrument has been validated by 3 experts, namely 2 lecturers and 1 teacher. Before data processing, all students' pretest and posttest answers are checked and scored. For science process skills tests, correct answers are given a score of one, and incorrect or unanswered answers are given a score of zero.

To determine the improvement of students' science process skills, normalized average gain score data is used which is processed using equations developed by Hake in 1999, which shows in **Table 1**. To interpret the normalized average gain score, you can use the **Table 1**.

Table 1. Gain (g) criteria.

Value <g>	Criterion
$\langle g \rangle \geq 0.7$	High
$0.7 > \langle g \rangle \geq 0.3$	Average
$\langle g \rangle < 0.3$	Low

3. RESULTS AND DISCUSSION

The ability of STEM literacy of students in the aspect of knowledge can be seen from the multiple-choice test of 25 questions consisting of 12 questions to measure scientific literacy, 6 questions to measure mathematical literacy, and 7 questions to measure technological engineering literacy. There are 5 indicators of STEM literacy, namely explaining scientific phenomena, interpreting scientific data and evidence, formulating situations mathematically, understanding the principles of technology, and developing solutions to achieving goals in alternative energy materials. The increase in STEM literacy can be seen from the n-gain which

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shows that there is an increase with moderate criteria after learning using STEM modules is applied. A recapitulation of students' STEM literacy results can be seen in **Table 2**.

Table 2. Recapitulation of STEM literacy results.

Aspects	N	Pretest	Posttest	n-gain
STEM Literacy	36	44.11	82.67	0.69

Based on the **Table 2**, to determine how high the increase can be done with gain normalization analysis, from this study it was found that STEM literacy results experienced a moderate increase with an n-gain of 0.69. STEM learning can improve students' STEM literacy in various aspects, one of which is knowledge.

3.1. Improvements in Science Literacy

The science literacy trained in this study consisted of 12 multiple-choice questions. The increase in science literacy ability can be seen from n-gain by analyzing pretest and posttest results. The average pretest result was 44.91 and the posttest average was 81.25 with an n-gain of 0.66 which is in the medium category. The following is a recapitulation of the results of science literacy.

Based on **Table 3**, the results of research that has been conducted on the aspect of science literacy show that there is an increase in the ability of students in this aspect after applying STEM learning using modules on alternative energy materials.

In this study, aspects of scientific literacy are divided into two indicators, namely explaining scientific phenomena and interpreting scientific data and evidence. Indicators explaining scientific phenomena consist of 4 questions while indicators interpret scientific data and evidence consisting of 8 questions. A recapitulation of science literacy indicators can be seen in **Table 4**.

Based on **Table 4**, the results of explaining physical phenomena obtained a pretest of 43.06 and a posttest of 82.64 with an n-gain of 0.69 can be categorized as moderate. In the indicator interpreting scientific data and evidence, a pretest of 48.61 and a posttest of 78.47 with an n-gain of 0.58 can be categorized as moderate. Indicators of interpreting scientific data and evidence tend to be lower than explaining scientific phenomena because students have difficulty interpreting data, both in the form of tables and graphs.

Table 3. Recapitulation of science literacy results.

Aspects	Pretest	Posttest	n-gain
Science Literacy	44.91	81.25	0.66

Table 4. Recapitulation of science literacy results per indicator.

Science Literacy Indicators	Pretest	Posttest	n-gain
Explaining Scientific Phenomena	43.06	82.64	0.69
Interpreting scientific data and evidence	48.61	78.47	0.58

3.2. Improvements in Mathematical Literacy

Mathematical literacy is one of the pillars of STEM education. Mathematical literacy provides opportunities for students to play an active role in analyzing data and presenting data based on phenomena. Mathematical literacy in this study was tested using a test of 6 points with indicators of formulating situations mathematically. The average recapitulation

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of the increase in mathematical literacy is presented in **Table 5**. Based on **Table 5** before the application of learning using STEM-based modules, an average pretest of 37.96 was obtained, and after the application of learning using STEM-based modules, a posttest average of 0.71 was obtained with an n-gain of 0.71 in the high category.

Table 5. Recapitulation of mathematical literacy results.

Aspects	Pretest	Posttest	n-gain
Mathematical Literacy	37.96	81.94	0.71

3.3. Improvement in Technology-Engineering Literacy

In this study, technology-engineering literacy used 7 choice questions. Based on **Table 6**, shows that the results of technology-engineering literacy before applying STEM learning using STEM modules obtained an average pretest of 48.02. After the application of STEM-based learning using modules, a posttest average of 85.71 was obtained. The following is a recapitulation of the results of technology-engineering literacy.

Furthermore, to see the increase in technology-engineering literacy, a normality gain (n-gain) analysis is liquidated. Based on the results of the n-gain analysis, it was found that 0.73 can be categorized as high after applying STEM-based learning with modules. In this study, there are two indicators in the aspect of technology-engineering literacy, namely the industry explaining the principles of technology and indicators of developing solutions and achieving goals. The following is a recapitulation **Table 7** of technology-engineering literacy with two indicators.

Table 6. Recapitulation of technology-engineering results.

Aspects	Pretest	Posttest	n-gain
Technology-Engineering Literacy	48.02	85.71	0.73

Table 7. Recapitulation of technology-engineering literacy results per component.

Technology-Engineering Literacy Component	Pretest	Posttest	n-gain
Understand the principles of technology	50.93	87.04	0.74
develop solutions and achieve goals	30.56	77.78	0.68

Table 7 shows the results of technology-engineering literacy, indicators of understanding technology principles with an average pretest of 50.93 and an average post-test of 87.04. After a normalization analysis, n gain was obtained at 0.74 in the high category. In the indicator of developing a solution and achieving the goal of a pretest average of 30.56, a posttest average of 77.78 with an N-gain value of 0.68. Thus, the results of technology-engineering literacy on indicators of developing solutions and achieving goals show moderate improvement.

The highest n-gain is found in the indicator of understanding the principle of technology, This happens because when learning using STEM modules students are directly involved in making mini solar systems. From direct learning experience, students can easily understand the principles of technology. On the question with the indicator Interpreting scientific data and evidence, there was an increase but with an n-gain of 0.58. This value is the lowest when compared to other indicators. This happens because students do not understand the basic concept of reading data in the form of tables and graphs. Therefore, students have difficulty

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analyzing and interpreting the right data based on graphs. But overall, physics learning using STEM-based modules can improve students' STEM literacy skills.

4. CONCLUSION

The application of STEM learning to alternative energy materials can improve STEM literacy aspects of high school student's knowledge. This can be seen from the results <g> obtained at 0.69 in the medium category. The increase in STEM literacy in the knowledge aspect of science literacy results <g> obtained by 0.66 in the medium category, n-gain basic mathematical literacy obtained by 0.71 in the high category, and technology-engineering n-gain literacy obtained by 0.73 in the high category.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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