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STEM Learning Model Implementation Assisted by E-Module on Problem Solving and Mathematical Literacy Abilities

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Abstract:
This research aims to analyze the effect of STEM model learning on problem-solving ability and mathematical literacy ability. The research uses a quantitative approach with a Quasi-Experimental research design in the form of a Pre-Post Group Design. The research instruments are learning instruments, tests, interviews, and test question validation questionnaires. The data analysis results using the Wilcoxon test show that there is an influence of using the STEM learning model on problem-solving abilities and mathematical literacy with a p-value lower than 0.05. The STEM learning model improves the students' problem-solving abilities in the medium category (N-Gain = 0.4644) and mathematical literacy abilities in the medium category (N-Gain = 0.3889). These results conclude that the STEM learning model can be an alternative solution to improving students' problem-solving abilities and mathematical literacy.

Keywords: E-Module, Mathematics Literacy, Problem Solving, STEM

1. Introduction

In the current Industrial Revolution 4.0 era, some must possess 21st-century abilities or skills, namely critical thinking and problem-solving, creativity and innovation, and communication and collaboration. Educational entities like universities must be able to provide their students with these skills so they can compete or survive in this globalization age. Also, skills in searching, managing, conveying information, and using information and technology appropriately are necessary skills the students should have. Cheng (2017) stated that 21st-century skills and literacy include basic skills as the provisions in education.

21st-century learning requires people to have technology and information management skills, learn and innovate. They should also have a career global awareness, and characters to compete healthily based on science and technology. Thus, education is there to answer these challenges. One approach that has the characteristics to respond to the demands of 21st-century learning is STEM (Science, Technology, Engineering, and Mathematics). Torlakson (2014) stated that these four aspects are a harmonious combination of problems that occur in the real world and problem-based learning. This approach can create a cohesive learning system and active learning. This is because all four aspects run simultaneously to solve the problems. The STEM approach reflects how science is reflectively integrated with technology into techniques. All of these disciplines contain mathematical elements as the parent of science (Yakman, 2012).

One of the cognitive abilities that can be improved with STEM is literacy (Kemdikbud, 2018). Mathematical literacy helps someone to understand the role or use of mathematics in daily life while using it to make the right decisions as a constructive, caring, and thinking citizen (OECD, 2013). In line with Mahmud (2019), literacy is necessary in all aspects of life, at home and in society. Literacy skills include the ability, confidence, and willingness to engage with quantitative or spatial information to make informed decisions in all life matters (Alberta, 2018).

Mathematical literacy is the knowledge and skills to apply different kinds of numbers and symbols related to basic mathematics to solve practical problems in everyday life and then analyze information displayed in various forms and interpret the analysis results to predict and make decisions (Kemdikbud, 2017). Mathematical literacy can be seen from the skills to formulate, apply, and interpret mathematics in many contexts, including the ability to reason mathematically and use concepts, procedures, and facts to describe and explain or predict certain phenomena or events (OECD, 2013).

Initial research on mathematics education students has shown that third-semester students' mathematics literacy is still low. Of the 23 students, only seven can analyze arguments well in solving descriptive statistics questions. Not a single student can draw the right conclusions. It means that no student has been able to reach the mathematical literacy indicators.

This problem is due to several factors. Based on the interviews, the students said that in learning descriptive statistics, they were not used to discussing mathematical literacy. Besides, it is closely related to the teaching materials during the learning process. Initial observation shows that 83.4% of students have used reference books and used articles from the internet. There is no availability of modules as one of the teaching materials in lectures. Learning using modules can develop students' independent abilities. The learning module can train their independence with the components contained in it. The modules are prepared systematically and interestingly which include material contents, methods, and evaluations (Basilotta, 2017).

STEM is also closely related to mathematics. Mathematics is inseparable from problem problem-solving process. STEM learning can strengthen students' interest in learning, making learning more meaningful. It also helps the students solve problems in real life (Indri, 2017). The STEM approach is currently an alternative to science learning that can build a generation capable of facing the challenging 21st century (Hannover, 2017). Problem-solving is an integral part of mathematics learning (NCTM, 2000). Krulik & and Rudnick (1995) defined problem-solving ability as an individual's means of using previously possessed knowledge and abilities to synthesize and apply to new and different situations. Anderson (2009) explained that problem-solving is a life skill that involves the processes of analyzing, interpreting, reasoning, predicting, evaluating, and reflecting. Therefore, problem-solving ability is the ability to apply previously owned knowledge to new situations that require high-level thinking processes.

Based on the descriptions above, the researchers are encouraged to implement the STEM learning model assisted by descriptive statistics e-modules. It is expected that this module-assisted learning model can make learning more meaningful. Besides, it aims to provide the students with STEM-based learning, mathematical problem-solving abilities, and mathematical literacy skills.

2. Research Methods

This research uses a quantitative approach with a Quasi-Experimental research design in the form of Pre-Post Group Design and data analysis by comparing the pretest and post-test scores. In this research design, there is a class that receives STEM learning model treatment. Table 1 below overviews the research design.

Table 1: Research design

Pre-test	Treatment	Post-test
Y_1	X	Y_2

Note:

Y_1 = Pre-test before treatment

X = Treatment on experimental class

Y_2 = Post-test after treatment

This research subject is the students of the Mathematics Education Study Program; the research population is all odd-semester students in the 2023/2024 academic year. The sample is taken using a cluster random sampling technique. One experimental class is taken as the research sample. The research instruments are 1) learning instruments consisting of RPS, RPP, and STEM modules; 2) test instruments, namely initial ability test questions and final tests; 3) interview instruments, and; 4) test question validation questionnaires consisting of validation questions test of problem-solving and mathematical literacy abilities.

The data analysis techniques include 1) analysis of test instrument data, namely tests of question validity, reliability, differentiation, and level of difficulty; 2) data analysis of test results for problem-solving and mathematical literacy abilities which consist of initial data analysis to check the balance of the class with prerequisite tests (normality and homogeneity tests), and; 3) final data analysis using the pre-test and post-test results after the research. Before the final data analysis, it is necessary to carry out a normality test first before having the Paired Sample T-Test. If the data is not normally distributed, the test used is the Wilcoxon test. Meanwhile, the N-Gain test aims to determine the increase from the treatment given. Table 2 below shows the N-Gain categories.

Table 2: N-Gain category

N-Gain Value	Category
$g \geq 0{,}7$	High
$0{,}3 \leq g < 0{,}7$	Medium
$g < 0{,}3$	Low

3. Result and Discussion

This research particularly implements a STEM learning model assisted by e-modules in descriptive statistics courses. This research uses a quantitative approach with a Quasi-Experimental research design in the form of a Pre-Post One Group. The design and data analysis run by comparing the pre-test and post-test scores. The results are based on the analysis that has been carried out as follows.

3.1 Prerequisite test analysis

The normality test aims to check if the sample used is normally distributed or not. The normality test is the Liliefors test. The table below shows the results of the normality test on problem-solving abilities and mathematical literacy.

Table 3: Normality test for problem-solving ability

Stage	L_{count}	L_{table}	Result
Pre-test	0,2244	0,1419	Not normally distributed
Post-test	0,1796	0,1419	Not normally distributed

The table above shows that the normality test on the pre-test scores produces L_{count}=0.2244 and L_{table}=0.1419. Because L_{count} is higher than L_{table}, it can be concluded that the pre-test scores are not normally distributed. Then, the post-test scores produce L_{count} =0.1796 and L_{table} =0.1419. Because L_{count} is lower than L_{table}, it can be concluded that the pre-test scores are not normally distributed.

Table 4: Normality test for mathematical literacy ability

Stage	L_{count}	L_{table}	Result
Pre-test	0,1961	0,1419	Not normally distributed
Post-test	0,0733	0,1419	Normally distributed

The table above shows that the normality test on the pre-test scores produces L_{count} =0.1961 and L_{table} =0.1419. Because L_{count} is higher than L_{table}, it can be concluded that the pre-test scores are not normally distributed. Then, the post-test scores produce L_{count} = 0.0733 and L_{table} =0.1419. Because L_{count} is lower than L_{table}, it can be concluded that the post-test scores are normally distributed.

3.2 Hypothesis 1 analysis (Wilcoxon test analysis)

The pre-test and post-test scores on problem-solving and mathematical literacy abilities do not meet the normality criteria. Therefore, there will be a non-parametric test called Wilcoxon Test. The table below shows the results of the Wilcoxon test on problem-solving and mathematical literacy abilities.

Table 5: Wilcoxon test of problem-solving ability

Treatment	$P - value$	Result
Pre-test dan Post-test	0,000	There is a difference

The table shows that the Wilcoxon test on the pre-test and post-test scores produces a p-value = 0.000. Because the p-value is lower than 0.05, there is a difference in problem-solving abilities before and after treatment.

Table 6: Wilcoxon test of mathematical literacy ability

Treatment	$P - value$	Result
Pre-test dan Post-test	0,000	There is a difference

The table shows that the Wilcoxon test on the pre-test and post-test scores produces a p-value = 0.000. Because the p-value is lower than 0.05, there is a difference in mathematical literacy abilities before and after treatment.

3.3 Hypothesis 2 analysis (N-gain test analysis)

Besides the Wilcoxon test, the N-Gain test aims to determine the increase in the treatment given. The table below shows the results of the N-Gain test on problem-solving and mathematical literacy abilities.

Table 7: N-Gain test of problem-solving ability

Treatment	$N - Gain$	Category
Pre-test and Post-test	0,4644	Medium

The table shows that the N-Gain test on the pre-test and post-test scores produces N-Gain=0.4644 in the medium category. It means that there is an increase in the average score in problem-solving ability after treatment with an increase of 0.4644 (medium).

Table 8: N-Gain test of mathematical literacy ability

Treatment	$N - Gain$	Category
Pre-test and Post-test	0,3889	Medium

The table shows that the N-Gain test on the pre-test and post-test scores produces N-Gain=0,3889 in the medium category. It means that there is an increase in the average score in mathematical literacy ability after treatment with an increase of 0,3889 (medium).

Tables 5 and 6 generate the p-value = 0.000. Because the p-value is lower than 0.05, there are differences in mathematical problem-solving abilities and mathematical literacy before and after treatment. For its implementation, the learning process uses the STEM model assisted by e-modules. In the first stage, students are guided to ask questions and define problems to observe phenomena in the e-module.

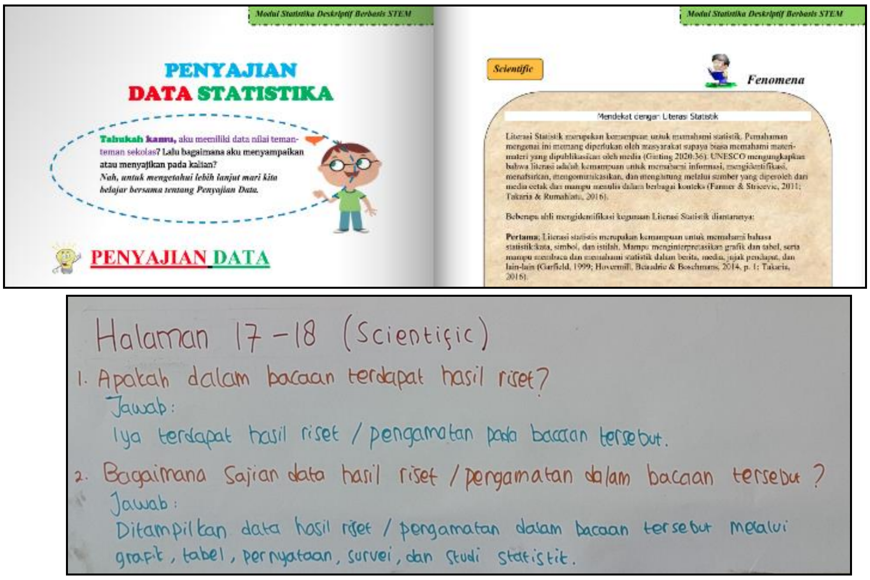

Figure 1: Display of the e-module and examples of students' answers

Stages 2 and 3 include activities to develop and use models to plan and carry out investigations in the students' group discussions.

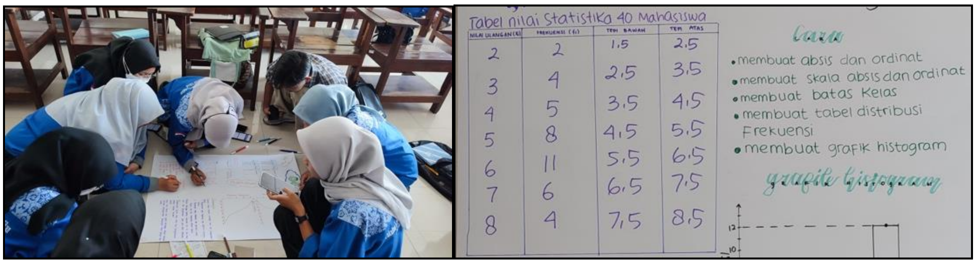

Figure 2: Discussion and investigation process

In stage 4, students analyze and interpret data from the problems presented. Then, stage 5 includes activities using mathematics and computing which can be seen from the problem-solving process.

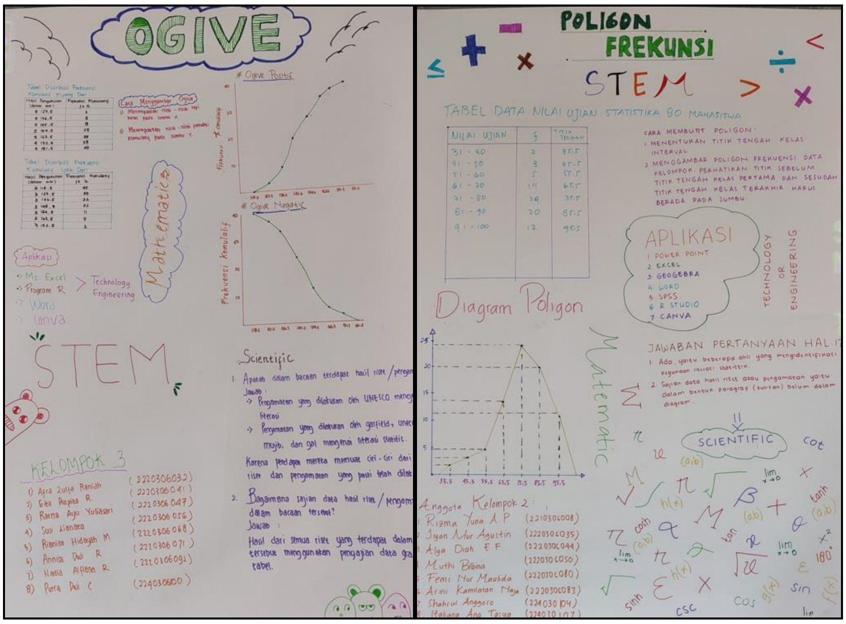

Figure 3: Students' works by collaborating the STEM elements

In the final stage, the students have been able to argue and evaluate their work in front of the class. Then, to test individual abilities, there is a post-test that has been adjusted to measure problem-solving and mathematical literacy abilities.

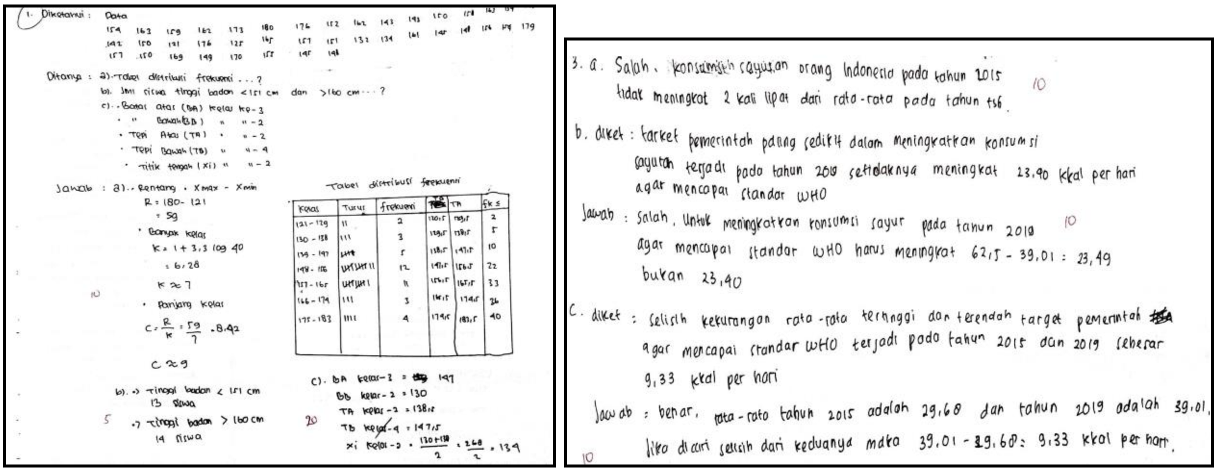

Figure 4: Example of students' post-test answers

The N-gain values reflect the students' problem-solving abilities. The problem-solving ability score is 0.4644. Thus, there is an increase in students' mathematical problem-solving through the STEM learning model in the moderately increasing category. This is in line with Sudarsono et al. (2022) who found states that the STEM learning model can influence and improve students' abilities, especially problem-solving.

Next, the N-gain value shows students' mathematical literacy abilities. The N-gain value in problem-solving ability is 0.3889. Thus, there is an increase in students' mathematical literacy through the STEM learning model in the moderately increasing category. This is in line with Kelana et al. (2020) who explained that the STEM learning model can influence and improve students' abilities, especially mathematical literacy.

4. Conclusions

The research findings conclude that the STEM learning model can influence problem-solving abilities and mathematical literacy. It can also improve the students' problem-solving abilities. The data analysis results show that the experimental class does not meet the normal distribution, so there is a Wilcoxon test. The Wilcoxon test results show that the p-value for problem-solving ability and mathematical literacy is the same, namely 0.000. It means there is a difference in problem-solving ability and mathematical literacy before and after treatment. Next, the N-Gain test results show an increase in problem-solving ability of 0.4644 (medium) and mathematical literacy ability of 0.3889 (medium).

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