STEM application through simple technology to improve technology literacy

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Abstract. This study aims to examine the effect of applying the STEM (Science, Technology, Engineering and Mathematics) approach through simple technology on the technology literacy of students in a simple harmonic motion content. This research method is one group pretest-postest design. There are two classes involved, namely the modeling and implementation class. Both classes use the STEM approach through simple technology. The research subjects were grade X students at MAN 1 Yogyakarta. The research sample consisted of 26 students in the STEM modeling class and 24 students in the STEM implementation class, which were determined by random sampling. The research instrument used a technology literacy description test. Data were analyzed quantitatively using the SPSS 21.0 program. The analysis shows that there is an increase in the results of the pretest-posttest technology literacy ability of students in both classes. Technology literacy of students in both classes shows the same N-Gain which is 0.46 (in the moderate category). These results indicate that the STEM approach through simple technology on simple harmonic motion content can influence students' technology literacy enhancement.

Keywords: *STEM, technology literacy, physics*

1. Introduction

There are still many problems that occur in learning physics. Currently, the teacher is still delivering physics material abstractly and theoretically [1]. Students still have difficulty in mastering concepts related to one of the physical chapters, one of which is a simple harmonic motion [2]. Difficulty of the simple harmonic motion because of students still confuse in applying simple harmonic motion in daily life [3]. Teachers should implement good and optimal instructional strategies so that students can complete their learning tasks, such as by applying a learning approach.

The STEM approach becomes a meta-disciplinary approach and needs to be delivered to students in an interdisciplinary manner [4]. The STEM approach allows students to gain experience in finding answers to questions, conducting scientific investigations, design techniques related to the STEM discipline [5]. So students can develop their own identities as STEM learners through science, mathematics, technology, and engineering. Some developed countries develop STEM approaches (science, technology, engineering, and mathematics) as a solution to the challenges of the 21st century [6]. The STEM approach provides the opportunity for teachers to show students the concepts, principles, and techniques of science, technology, engineering and mathematics. This STEM approach usually used in an integrated way in everyday life [7]. The STEM approach will connect schools, the world of work, and the global world so that the development of STEM literacy in schools enables students to compete in a new era of knowledge-based [8]. The teacher must prepare needed in the learning process with the STEM approach carefully [9]. However, research on the integration of STEM in learning is still rarely done [10]. In Indonesia, the STEM approach has not been widely used, obstacles occur in teachers who apply the STEM approach, which links physics with real-life [11]. Teachers are still struggling, confused and have not yet developed an education that integrates the STEM approach [12].

According to the latest 2013 curriculum revision in 2017, one of the main focus on the implementation of K-13 is strengthening literacy [13]. 21st-century students must be able to solve various problems by thinking creatively and using technology. There are four main domains determined in 21st century skills, one of which is digital era literacy such as technology literacy [14]. Facing the Industrial Revolution 4.0 era, teachers must play a role in increasing new literacy, namely technological literacy [15]. It is important for students to have technology literacy so that they are more competitive and can participate in society, but the evidence shows the lack of technological literacy, due to limited understanding related to the characteristics of technology [16]. The era of technology disruption requires mastery of a combination of technologies such as physics, digital and biology [17]. Technology literacy is important to be improved because in the era of the industrial revolution is closely related to technology [18]. However student's technology literacy related to the definition and way of working for technology is still lacking [19]. Some studies still have limitations in measuring students' ability to understand the meaning of the nature of technology [20]. Until now, instruments to measure the technology literacy of students are generally still rarely applied [21].

Based on several studies related to the STEM approach above, so in this study I applied the STEM approach to find out its effects on students' technology literacy, especially on simple harmonic motion material.

2. Research method

2.1. Research design and participant

This study uses one group pretest-postest design by applying STEM learning in both classes (STEM modeling and implementation). But in this study using 2 classes to make it more convincing. The STEM modeling class is taught by researchers while the STEM implementation class is taught by physics teachers, for more details, presented in table 1.

Table 1. Research design by giving pretest and posttest.

Class	Pretest	Treatment	Postest
STEM Modeling	O_1	X_1	O_2
STEM Implementation	O_1	X_1	O_2

O_1 shows a technological literacy test before treatment. X_1 shows the STEM treatment through simple technology. While O_2 shows a technological literacy test after treatment. An initial test (pretest) is given at the beginning of learning to students of the STEM modeling and implementation class. At the end of learning, a final test (posttest) is conducted after the student participates in STEM learning. This research was conducted during the learning process of a simple harmonic motion content in the academic year 2018/2019. The research subjects were 10th grade students at MAN 1 Yogyakarta. The research subject consist of 26 students in the STEM modeling class (X MIA 1) and 24 students in the STEM implementation class (X MIA 2). The research object was obtained based on purposive sampling by looking at certain criteria and reasons. Classes were used as research subjects, namely classes that were between high-ability classes and low-ability classes that were observed based on observations.

2.2. Research procedure

The research procedure includes the planning, implementation and final stages.The steps taken in the study, starting with initial observations related to learning in school and interviews with physics teachers and students. The results found that teachers have not applied the STEM approach in 2013 curriculum and practicum activities are rarely carried out in the learning process. Learning still tends to be teachercentered, so students are less active in participating in learning activities. Furthermore, researchers conducted material analysis based on facts, principles, laws and the theory of simple harmonic motion.

The planning stage is the making of a Learning Implementation Plan (RPP), Student Worksheet (LKPD) assisted by simple spring balance media by adjusting the STEM approach and technology literacy questions. Technology literacy questions are developed based on aspects of technology literacy assessment from the International Technology and Engineering Association (ITEEA). The questions are in the form of a description with a total of 4 questions for aspects of technology introduction and understanding. The data obtained are in the form of pretest and posttest of students' technology literacy. The RPP, LKPD, spring balance media and technology literacy test instruments are validated by the validator, if there are suggestions and input to be revised by researchers. RPP validation sheets, LKPD, spring balance media and technology literacy test instruments provided 2 choices, valid and invalid. In this study, 2 validators are needed to assess the validity of the instruments and media used. If the instrument has been declared valid by the validator, the researcher is ready to conduct research to measure the learner's technology literacy (implementation phase). While the final stage is to conduct data analysis, discussion,and conclusions. Data collection techniques in the form of written tests.

2.3. Data analysis
The enhancement of technology literacy after participating in STEM learning is obtained by calculating the average value of normalized gain (N-Gain) in the STEM modeling and implementation class. The division of categories for obtaining N-Gain values is presented in table 2.

Table 2. Classification of n-gain scores.

N-Gain scores	Category
$g > 0.7$	High
$0.3 < g < 0.7$	Moderate
$g < 0.3$	Low

The N-gain value and the average pretest-posttest technology literacy of students in each class can be analyzed using SPSS 21.0. Before conducting the test, the assumptions of the analysis prerequisites must be met. Prerequisites for analysis include tests of normality and hypothesis. The normality test is used to determine the distribution of data normally or not. The normality test is done by using Shapiro Wilk (SPSS 21.0) because this study uses a relatively small sample. The data requirements are normally distributed if the probability is $p > 0.05$ in the normality test for Saphiro Wilk. Initially, researchers wanted to use parametric statistical analysis with paired sample t test to test the hypothesis, but because the research data were not normally distributed, the researchers used another alternative, the Wilcoxon test.

2.3.1. Hypothesis test. H_0 : there is no difference in the technological literacy abilities of pretest and posttest learners, which means there is no influence of the use of the STEM approach to technology literacy in students of class X MIA 1 (STEM modeling) and class X MIA 2 (STEM implementation) MAN 1 Yogyakarta.

H_a : there is a difference in the technological literacy skills of pretest and posttest students, which means that there is an influence of the use of the STEM approach to technology literacy in students of class X MIA 1 (STEM modeling) and class X MIA 2 (implementation of STEM) MAN 1 Yogyakarta

This hypothesis was answered using the Wilcoxon test with the help of the SPSS 21.0 program for windows. The decision making criteria is that H_0 is rejected if the asymp.sig. (2-tailed) value <0.05.

2.4. STEM approach
The STEM learning stage in this study uses the syntax of the discovery learning model. The syntax of the discovery learning model consists of stimulation, problem identification, data collection, data processing, verification, and generalization. Learning activities using the discovery learning model are presented in table 3.

Table 3. Syntax of the discovery learning model.

Syntax of the Discovery Learning Model	Learning Activities
Stage 1: Stimulation	Students are given a stimulus by watching a short video related to the application of Hooke's Law in everyday life
Stage 2: Problem Statement	Learners identify a problem from the video shown
Stage 3: Data Collection and Data Processing	Learners conduct experiments using spring balances and looks for some information from various sources to answer questions in the LKPD
Stage 4: Verification and generalization	Each group concludes the learning activities and presents the results of the discussion in front of the class

The STEM (science, technology, engineering and mathematics) elements are integrated into the learning activities. The STEM elements are presented in table 4.

Table 4. STEM elements integrated in learning activities.

Component	Explanation
Science	Simple harmonic motion (spring)
Technology	Simple spring balance
Engineering	The design / design of a simple spring balance
Mathematics	Hooke's Law Equation

The teacher distributes a simple spring balance to 6 groups. Figure 1 shows the simple spring balance used in STEM learning of simple harmonic motion. Students are assigned to fill in the Student Worksheet (LKPD) by doing mass variations on the use of a simple spring balance and also answering questions to the LKPD. Activities undertaken require students to be able to apply their understanding of technological literacy such as understanding the use, characteristics, working principles and application of physical laws in simple spring balances.

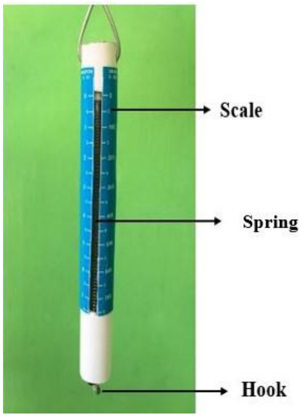

Figure 1. Simple spring balance used in STEM learning .

Figure 1 shows a simple spring balance used by students in learning. Figure 1 shows the components of a simple spring balance which includes scale, spring and hook.

3. Results and Discussion

The results of the validation of the Learning Implementation Plan (RPP), Student Worksheet (LKPD), technology literacy test description and simple spring balance were declared valid with revision by 2 expert lecturers. The technological literacy ability of students is measured using the results of the pretest and posttest. Pretest questions are given before the class gets STEM learning treatment while posttest is after STEM learning. A comparison of the average pretest and posttest literacy of students' technology was analyzed using descriptive statistics on SPSS 21.0. The average pretest and posttest scores in the STEM modeling and implementation class is presented in table 5.

Table 5. Average pretest and posttest scores in the STEM modeling and implementation class.

Class	Test	N	$\bar{x}$
STEM modeling	Pretest	26	35.70
	Posttest	26	64.42
STEM implementation	Pretest	24	40.50
	Posttest	24	69.17

Table 5 shows the average scores of the pretest and posttest results for the STEM modeling and implementation class. The average value of the pretest-posttest class in the STEM modeling classes were 35.70 and 64.42, respectively. The average pretest-posttest grades in STEM implementation classes were 40.50 and 69.17. The average results of the posttest score of each class are higher than the pretest. The results of the analysis of the average pretest and postest data can be seen in figure 2.

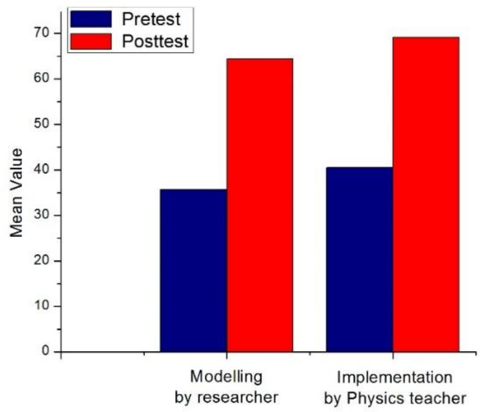

Figure 2. Average pretest and posttest grades for STEM modeling and implementation.

The graph shows that the average posttest score of 64.42 in STEM modeling class is greater than the average pretest value of 35.70. The results of the posttest average value of 69.17 in STEM implementation class are also greater than the average value of the pretest which is worth 40.50. These results can be caused by students when working on pretests do not yet have concepts/knowledge related to technological literacy in simple harmonic motion material. Students after following STEM learning through a simple spring balance, the average value of their posttests increases.

The results of the prerequisite test data analysis include tests of normality and hypothesis. The results of the normality test for the STEM modeling and implementation class are presented in table 6.

Table 6. Normality test.

Class	Test	Sig.	Category
STEM Modeling	Pretest	0.198	Normally distributed
	Postest	0.445	Normally distributed
STEM Implementation	Pretest	0.041	Not normally distributed
	Postest	0.060	Normally distributed

Table 6 shows that the pretest data in the STEM implementation class is not normally distributed because the significance value is less than 0.05. Data not normally distributed can be caused by data less than 30. Initially, researchers wanted to use parametric statistical analysis with paired sample t test to test the above hypothesis, but because the research data were not normally distributed, the researchers used Wilcoxon test. The results from the Wilcoxon test can be seen in table 7.

Table 7. Result of Wilcoxon test.

	Postest-Pretest
Z	-6.157
Asymp. Sig. (2-tailed)	0.000

Based on table 7, it is known that asym.sig. (2- tailed) is worth 0.000. the value is smaller than 0.05, it can be concluded that H_0 is rejected, meaning that there are differences in the ability of students' literacy in technology for the pretest and posttest. So it can be concluded that, there is an influence of using the STEM approach through simple technology on the technology literacy ability of students in class X MIA 1 (STEM modeling class) and class X MIA 2 (STEM implementation class) MAN 1 Yogyakarta.

The improvement of technology literacy ability is calculated using the normalized gain formula (N-Gain) based on the acquisition of pretest and posttest data on technology literacy. The N-Gain value can be obtained through the SPSS 21.0 program. N-Gain technology literacy in STEM modeling and implementation classes are presented in table 8.

Table 8. N-Gain technology literacy.

Class	N-Gain	Category
STEM Modeling	0.46	Moderate
STEM Implementation	0.46	Moderate

Table 8 shows that the N-Gain of both STEM modeling and implementation classes are 0.46. Thus, an increase in the average value of pretest-posttest modeling and implementation of STEM in the moderate category.The STEM approach can help students contextualize the principles of physics to improve their learning outcomes. Students can apply the concepts of science, technology, engineering and mathematics in the technology used. The technology used in this study is a simple spring balance. The experience of students in using a simple spring balance allows them to build an understanding of the relationship between concepts. Technology literacy has indicators that include students able to understand the characteristics, principles of technology, able to explain the physical magnitude of harmonious motion as simple as technology. The results of this study support previous research which states that the STEM approach provides a major influence in increasing technological literacy [23]. The STEM approach through technology can also be applied and affect the technology literacy of students [24].

4. Conclusion

The average value of students from both classes also increased after participating in STEM learning through simple technology. So it can be concluded that, there is an influence of using the STEM approach through simple technology on the technology literacy ability of students in class X MIA 1 (STEM modeling class) and class X MIA 2 (STEM implementation class) MAN 1 Yogyakarta.

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