

Application of STEM learning approach through simple technology to increase data literacy

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Abstract. This study aims to investigate the STEM approach's effect on data literacy through simple technology on the theory of spring vibration. The research method used a quasi-experimental design with one group pretest posttest design. The study was conducted in class X MIA 2 MAN 1 Yogyakarta with 26 students. Data collection used pretest and posttest scores as measurement of data literacy. Based on data analysis results, this study obtained an enhancement in data literacy abilities. It can be seen in the N-gain test result. The results showed that 54% of students had data literacy in the high category, 42% in the medium category, and 4% in a low category. This study shows that there is an increase in student data literacy abilities after they are learning with the STEM approach through simple technology.

Keywords: *STEM, data literacy, simple technology, spring vibration*

1. Introduction

The 21st century is marked by the era of the industrial revolution 4.0 as a century of openness or a century of globalization, which means that human life in the 21st century underwent a fundamental change that is different from the order of life in the previous century. Even learning that must be done by teachers must be oriented to 21st century learning, which has the following characteristics: 1) a student-centered learning approach; 2) students are taught to be able to collaborate; 3) learning materials related to problems faced in everyday life, learning must enable students to connect with their daily lives, and 4) in an effort to prepare students to become responsible citizens, schools must be able to facilitate students to get involved in the social environment [1]. Most educators still convey physics subject matter with conventional approaches. The learning that is carried out results in a lack of student participation. Learning requires educators who not only provide unidirectional information because it will affect the success of the learning process [2]. This implies that learning strategies in the 21st century must have a learning syntax that prioritizes the needs of students. Teachers as facilitators of learning in the school environment must be more creative and innovative in creating a learning climate in the classroom so that students are curious [3].

The approach of Science, Technology, Engineering, and Mathematics (STEM) as one of the learning approaches that can accommodate the characteristics of 21st century learning. STEM as an approach where Science, Technology, Engineering, and Mathematics are integrated with a focus on the learning process of problem-solving in real life, STEM learning shows students how concepts, principles of science, technology, engineering, and mathematics are used in an integrated way to develop products, processes, and systems that provide benefits to human life. The integration of the STEM approach will



help students in analyzing and solving problems that occur in real life so students are ready to work [4], [5]. The Inquiry, Discovery Learning, Problem Based Learning, and Project-Based Learning models are recommended as STEM-based learning models because they are in line with the 2013 curriculum goals and 21st century learning development. These learning models have a syntax in common that is student-centered learning [3]. The STEM approach was adopted to strengthen the implementation of the 2013 Curriculum [6]. Permendikbud No. 23 of 2017 states that one of the things that is strengthened from the 2013 curriculum revised in 2017 is strengthening literacy. One of the government policies is about new literacy which shifts old literacy. This new literacy is in line with the 2013 curriculum revision conducted by the government [7]. One of the new literacy movements launched by the Government is data literacy [8].

The SDL (Science Data Literacy) project has examined the data literacy of students, the results of which show the level of awareness of data management problems that are still very low. In line with learning using the STEM approach, students at all levels need to improve their data literacy, namely the ability to create and use various forms of data [9] – [13]. Data is a core component of science, students need to develop a full appreciation of the importance of data as scientific evidence and understand how to properly analyze and interpret it [13]. Schools need to identify, define and build various aspects of data literacy and be implemented throughout the curriculum in the school [14].

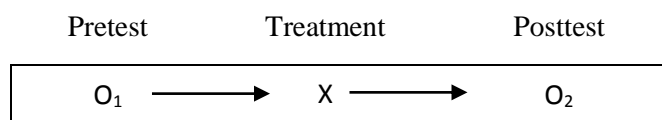
Physics as a subject whose theory can be developed for development technology [15]. Get springs as one of the materials whose principles can be applied in various fields of technology, one of which is simple spring technology. Simple technology can be created from objects found around cans, plastics, etc. into technology that is easy for students to use [16]. The simple technology of turning springs in this study uses simple materials such as wire, pipes, and used springs.

Based on these problems, it is very interesting to study learning that can help students improve data literacy. The problem with this research is (1) Is there an influence of STEM learning approach on students' data literacy? (2) How to increase students' data literacy using the STEM learning approach? The STEM approach in this research is implemented through the use of Discovery Learning-based learning models using simple technology

2. Research Method

This research was conducted using the quasi-experimental design research method with one group pretest and posttest design. this study uses one class, namely the experimental class with the application of learning using the STEM approach integrated the discovery learning model through simple technology. Following is the scheme of one group pretest and posttest design [17].

Table 1. Research design one group pretest-posttest design.



Information: O₁ = retest, to measure data literacy before subjects are given treatment, X = the treatment given is learning using the integrated STEM approach of the discovery learning model through simple technology and O₂: posttest to measure data literacy after the subjects are given treatment.

The sample of this study was students of class X MIA 2 semester 2 MAN 1 Yogyakarta in the 2018/2019 school year, totaling 26 students. The selection of class X MIA 2 is based on the advice of the teacher in the field of study and licensing from the school management concerned. This research was conducted from 5 March 2019 to 30 April 2019.

This study includes three stages. There are research preparation, research implementation and final stage of research. The preparation phase of the research begins with analyzing students, curriculum analysis, concept analysis, and concept maps. Then proceed with the preparation of learning tools in the form of a Learning Implementation Plan (RPP), Student Worksheet (LKPD) STEM and spring vibration

subject matter data literacy assessment instruments. The components and principles of making STEM RPP includes several things namely school identities, subjects, and classes / semesters, subject matter, time allocation, learning objectives, basic competencies and indicators learning achievement, learning materials, learning methods, media, tools, and learning resources, steps in learning activities, and assessment. Next, the researcher compiled a lesson plan using the Discovery Learning model consisting of (stimulation, problem statement, data processing, verification, and generalization). Integrating STEM through the analysis of STEM learning materials by describing each component. Following analysis of spring vibration analysis of subject matter on STEM learning.

Table 2. Analysis of spring vibration subject matter on STEM learning.

The realm of STEM	Explanation
Science	Spring vibration
Technology	Simple Technology
Engineering	Design of simple technology
Mathematic	Hooke's Law

The components and principles of LKPD preparation in this study were prepared by taking into account the steps in LKPD preparation. Integrating STEM based on embedded approach patterns [18]. The assessment instrument used is a matter of pretest-posttest to measure the increase in student data literacy. The item was consulted and validated by the expert (judgement expert). Concerning the form of essays with aspects of data analysis and reading data in the context of spring vibration. Expert validation results show that the data literacy assessment instrument is valid and can be used to retrieve research data.

The implementation phase of the study begins by providing a pre-test to measure the ability of the data literacy of students before being given treatment. The next step is to provide a STEM learning treatment integrated with the Discovery Learning model through simple technology. The simple technology in this study was designed and made by researchers using simple materials such as small pipe, used springs and wire mesh so that a simple spring balance technology is formed as shown in figure 1. After giving treatment, the next step is giving the final test to measure the ability of students' data literacy.

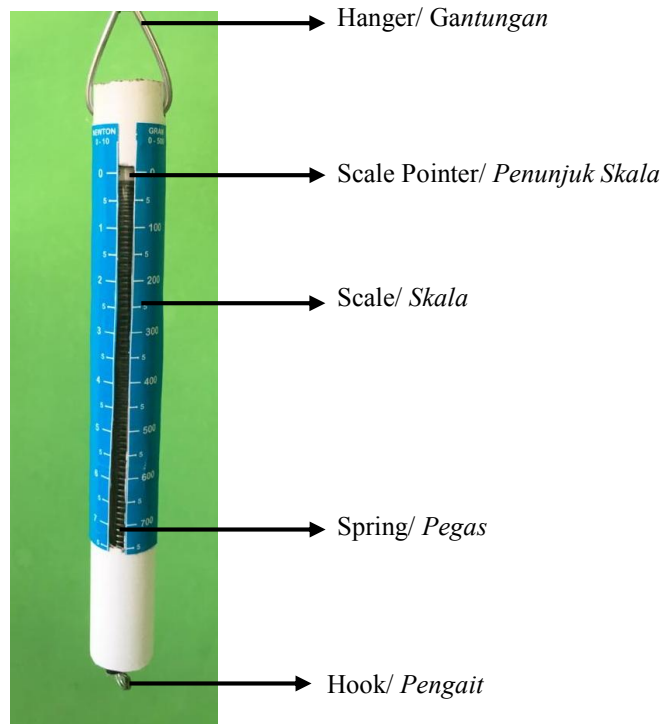


Figure 1. Simple spring vibration technology.

The final stage of the study is to process data from the results of the pretest and posttest, discuss and draw conclusions of the study. The analysis of the pretest and posttest assessment instruments for data literacy uses standard gain. The Standard Gain value uses the following equation:

$$\text{Std gain (sg)} = \frac{S_{\text{posttest}} - S_{\text{pretest}}}{S_{\text{max}} - S_{\text{pretest}}} \times 100\%$$

S_{posttest} are student's scores after they are given treatment by teacher. While S_{pretest} are student's scores before they are given treatment by teacher, and S_{max} are maximum score. The calculation results are then compared with the Standard Gain index category as follows [19]:

Table 3. Gain categories.

Gain	Categories
$sg > 70$	High
$30 < sg \leq 70$	Medium
$sg < 30$	Low

3. Results and Discussion

Pretest questions are given before the experimental class gets STEM learning through simple technology. Pretest questions are used to determine students' initial abilities. Furthermore, after the treatment of STEM learning through simple technology, students in the experimental group were given a data literacy test again for the second time (posttest questions). Pretest and posttest data scores were analyzed using descriptive statistics by looking for central trends (mean, median, mode) and dispersion (range, variance, standard deviation). The results of data analysis are presented in table 4.

Table 4. Results of data analysis.

	Pretest	Posttest
Mean	22.63	79.58
Median	20.00	82.00
Mode	2.50	81.00
Range	78.50	59.00
Variance	433.87	235.21
St. Deviation	20.83	15.34

Table 4 shows the relatively high difference in the concentration of pretest and posttest data literacy scores. The average pretest score was 22.63 and posttest 79.58. The median value of the pretest is 20.00 and posttest 82.00. At the pretest, the value that often appears is 2.50 and when the posttest the value that often appears is 81.00. If analyzed with the size of the dispersion shows that the distribution of pretest and posttest scores is different. The range at the pretest was 78.50 while the posttest was 59.00. The pretest variance value was 433.87 with a standard deviation of 20.83, while the posttest variance was 235.21 with a standard deviation of 15.34. Based on range values, it can be seen that the distribution of posttest values is more homogeneous because it has a smaller range value than the range value at the pretest. The smaller the value of the range the better the quality of the data, conversely the greater the value of the range the quality of the data will be increasingly bad. The highest value, lowest value, and average obtained during the pretest and posttest are presented in figure 2.

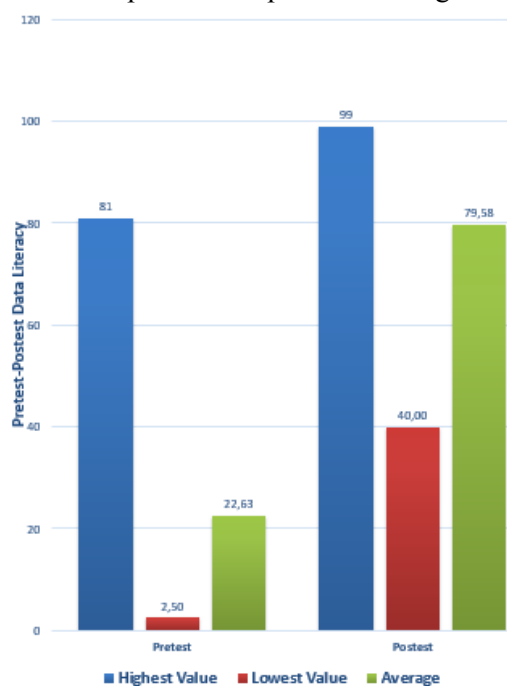
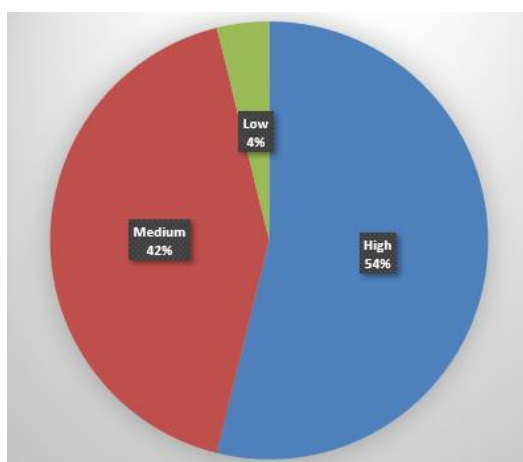
**Figure 2.** Highest value, lowest value and average of pretest-posttest data literacy.

Figure 2 shows that the lowest pretest value is 2.50, the highest value is 81 and the average pretest value is 22.63, while the lowest posttest value is 40, the highest value is 99 and the average posttest value is 79.58. This value indicates that the value is relatively higher in the posttest value than the pretest value. Furthermore, to find out the increase in students' data literacy, the analysis was performed using N-gain. The results of the N-gain score test are presented in table 5.

Table 5. N-gain score test results.

	Percentage (%) N-gain Score
Average	71.50
Lowest	16.67
Highest	98.92
Variance	483.26
St. Deviation	21.98

N-gain score test results in table 5 obtained the average percentage of N-gain score, the lowest percentage of N-gain score, the highest percentage of N-gain score, Variance and St. Deviation from the calculation results of the N-gain score test. The average value of the N-gain score was 71.50%, so the average experimental class students had an increase in data literacy with a high category. The lowest percentage of the N-gain score was 16.67%, while the highest percentage of the N-gain score was 98.92%. The N-gain score variance value is 483.26 with a standard deviation of 21.98. The percentage (%) of N-gain score achievement in the experimental class students can be seen in figure 3 below.

**Figure 3.** Percentage (%) achievement of N-gain.

The results of the pretest and posttest in the N-gain test there are three categories, namely the high category has a percentage value of $sg > 70$, the medium category is $30 < sg \leq 70$ and the low category is $sg < 30$. The results showed that 54% of students had an increase in data literacy with high criteria, 42% of students had an increase in data literacy with moderate criteria, and 4% of students had an increase in data literacy with low criteria. This shows that there is an increase in student data literacy after learning with the STEM approach through simple technology.

The application of the STEM approach in primary and secondary education is to develop STEM literate learners with the following details: 1) has three aspects of assessment in Education, namely: knowledge, attitudes, and skills to identify questions and problems in their life situations, explain phenomena nature, design, and draw conclusions based on evidence about issues related to STEM; 2) understand the special characteristics of STEM disciplines as forms of knowledge, inquiry, and design initiated by humans; 3) have an awareness of how STEM disciplines shape the material, intellectual and cultural environment; 4) has a desire to be involved in the study of issues related to STEM (for example energy efficiency, environmental quality, limited natural resources as constructive, caring and reflective citizens by using ideas of science, technology, engineering and mathematics [20].

Some relevant studies show the results of increased data literacy ability using the STEM approach [9] – [12]. Efforts to improve data literacy among students must be the highest priority to face challenges in the future so that all educators are recommended to be involved in educating all students using the

STEM approach or by using other approaches to improve data literacy so students can effectively face challenges in the future [10]. The use of data is a fundamental skill needed for STEM research practices, so the application of the STEM approach is suitable for increasing data literacy [11]. This century is experiencing very rapid development in the field of Information and Communication Technology (ICT) and the internet so that it requires data literacy which includes knowledge and skills in the data lifecycle, standards and practices of metadata, data tools, and communication and collaboration mechanisms that increasingly become qualifications that valuable in the world of work today, so STEM learning is very important to be applied to improve data literacy [12]. Data literacy skills are becoming increasingly important as the research/research environment develops by involving science, technical, engineering, and mathematics (STEM) in learning. The results show that scientific data literacy training needs to be provided at different levels and that training needs to adapt to the context, terminology, and workflow of scientific disciplines. The purpose of having data literacy at the undergraduate level is to train future science workforce with a strong understanding and skills in data management [13].

4. Conclusions

The application of the STEM learning approach through simple technology can increase data literacy. This can be seen from the results of N-gain which shows that the majority of students experienced an increase in the ability of high category data literacy. Further research related to the STEM approach, it is better for physics subject teachers or other subject teachers to improve students' data literacy by using the STEM approach to face challenges in the future.

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