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Simple harmonic motion experiments with the accelerometer sensor on a smartphone: Improving the problem solving-ability

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Abstract. The purpose of this study is to discover the improvement in students' problem solving abilities after learning activities through a simple harmonic motion experiment method using an accelerometer sensor on an smartphone and revealing student responses on it.Pre-experimental research design with one group pretest-posttest design was used in the study. The samples in this study were students of Class X IPA 1 of SMAN 1 Cilimus Kuningan, West Java. Data on the improvement of students' problem solving abilities were obtained through an essay test while the student's response data was obtained through the distribution of response questionnaires. The results showed that the problem-solving ability experienced by students increased in the moderate category. Whereas, the results of the responses of students showed that most of the students responded positively to the learning activities of the sensor accelerometer on this smartphone. So, experiment with smartphone has a potential for improving students problem solving skills.

1. Introduction

Physics learning emphasizes processes [1]. The process in physic learning is essential to develop scientific behavior and to create scientific products [2]. In general, the physics learning process has two components, the content and process. The content has relation to the knowledge structure while the process has relation to skills received to achieve, apply, and produce a knowledge [3].

Most schools and higher educations forsake the emphasis of process for comprehension level only, without the emphasis of developing an active process in which students have better opportunities to utilize a better thinking ability. One of the thinking abilities mentioned is student's abilities to solve problem [4]. The statement informs that a problem solving ability has an important role to achieve a good learning process.

Problem solving is one's ability to solve problems with non-automatic processes [5]. Problem solving enable students to be more effective at identifying, determining, and solving problems through logical and creative thinking [6].

In problem based learning there are several indicators that illustrate the problem solving ability of students. These indicators are descriptions of useful concepts, physics approaches, specific physics application, mathematical procedures, and logical developments [7].

Research on problem solving has been conducted since 1980 [8]. Many learning methods have been applied to hone students' problem solving abilities. Some methods that have been done by previous researchers include: using WBM (whiteboard math) converted to SCORM (Sharable Content Object Reference Model) and integrated in CMS (Course Management System) [9], using cooperative learning [10], using guidance peers [11], and using Heller's "Troubleshooting Strategy"[12].

An experimental activity using the experimental method is one of the methods in learning physics. Experimental methods have not yet been discovered and applied in physics learning to improve problem solving skills.

Unfortunately, the implementation of experimental activities requires adequate facilities while many schools do not have sufficient laboratory facilities. However, now the physics experiment activities at school can be actualized using an smartphone. Smartphone has many sensors that can be used for physics experiments. One of the sensor available on is the accelerometer sensor.

Accelerometer sensors can be used in physics experiments to analyze paired oscillation motion [13], and it can also be used to analyze angular magnitudes in the harmonic motion of a physical pendulum [14]. The use of accelerometer sensors in simple harmonic motion (SHM) material can be applied to the learning process with experimental methods to improve students' problem solving abilities (PSA). Therefore, this paper will describe the results of research on the use of accelerometer sensors on smartphones for experimental activities to improve students' problem solving abilities. The study also reveals student's responses regarding the learning process with the experimental method using the accelerometer sensor on an smartphone.

2. Research method

The research was conducted in SMA Negeri 1 Cilimus Kuningan Regency,West Java with X IPA 1 class as the sample.The method used in this study was *pre*-experimental method. This study used one group pretest-posttest design. Before given treatment, students were given a preliminary test of problem solving as preliminary data through a pretest. At the end of learning, after the treatment, students were given a final test of problem solving (posttest) in the form of essay [15]. Pretest and posttest data results were used to analyze the improvement of students' problem solving abilities in the form of n-gain. To find out the increase in the ability to understand the problems experienced by students, hypothesis testing was done using paired sample t-test, with a normality test being done beforehand. Simultaneously, students' responses regarding experiments with the accelerometer sensor on an smartphone were expressed through a questionnaire.

3. Result and discussion

3.1 Accelerometer sensor based learning activity

Physics learning in simple harmonic motion material begins with the activity of the introduction of material, which continues to experimental activities. Simple harmonic motion materials are divided into two parts, namely pendulum and spring's vibration. The experimental activity on pendulum material aims to determine the period of pendulum's vibrations by analyzing the influence of the pendulum rope length. The second experimental activity on spring's vibration material aims to determine the relationship between the restoring force to the deviation produced by the spring, and determine the period produced by the spring by analyzing the effect of mass.

The experimental activity is guided by a student worksheet. Student worksheet begins by presenting problems in daily life. Next, students are asked to write down experimental problems related to everyday problems that have been presented. Students are asked to determine the dependent variable and the independent variable of the experiment to be conducted, make predictions, make sketches of the experiment, arrange the experiment tools, take measurements, and analyze experimental data by looking at relationships between variables. The relation of learning activities and students' problem solving abilities is shown in Table 1.

Table 1. The relation of learning activity and problem-solving ability.

PSA indicator	SHM experiment on accelerometer sensor based on smartphone
Useful concept description	Identifying the problem presented and describing the physical information presented
Physics approach	Acknowledging the quantities recorded on the accelerometer sensor to solve the problem
Specific physics application	Analyzing the SHM chart and analyzing the relationship between the variables read on the accelerometer sensor
Mathematical procedure	Based on the quantities read in the sensor, being able to look for relationships between variables.
Logical development	Conducting SHM experiments using the accelerometer sensor repeatedly to check the consistency of the results of experiments actualized so that the the truth of the solution used can be checked.

3.2 Improvement in problem-solving ability

PSA improvement analysis was obtained by comparing the results of previous tests namely pretest and post-test, and the results of student's N-Gain calculations. The results of data analysis in this study can be described as follows.

3.2.1 N-Gain score analysis

3.2.1.1 Total N-Gain score analysis

The average score ofpretest, posttest and N-Gain of the students was shown on Table 2.

Table 2. Average score of pretest, posttest, and N-Gain

	Score		N-Gain	Interpretation
	Pretest	Posttest		
Total	984	2030	0.47	Moderate
Average	30.75	63.45		

Overall the N-Gain value obtained was 0.47. The N-Gain value indicates that the problem solving ability of students has increased moderately. This means that all students already have sufficient knowledge and are able to do problem solving [16].Although the ability of students has increased with a moderate category, the increase that occurred was insignificant. This could have happened because the learning process conducted was less than optimal so the learning activities were not as good as desired. As stated by Aulia & Sontani, a learning output is largely determined by the learning process that takes place [17].

3.2.1.2 N-Gain score analysis based on sub-material

The average score of the problem-solving tests based on sub-material was shown on Figure 1. The improvement of problem-solving ability on pendulum material is lower than the spring's vibration material. The pendulum material is the first material in learning activities. At the first meeting, students were still unfamiliar with some of the instructions contained in the student worksheet, so students were less active in the experiment, and the learning process run less than the maximum.
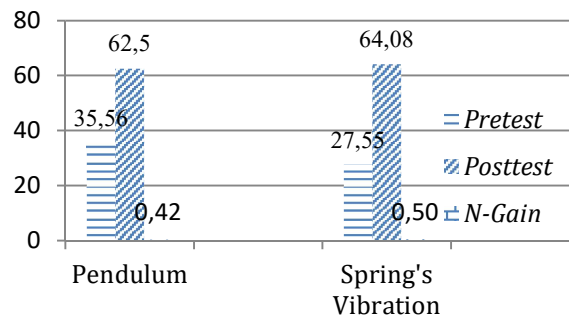
Figure 1. PSA analysis based on sub-material

Meanwhile, the second meeting of the spring's vibration material showed a greater increase than the first meeting. This material on the second meeting has a higher N-Gain value than pendulum material. It could be caused by students are beginning to get used to solving problems through experimental activities and students who were more adept at using the accelerometer sensor media on an smartphone.

3.2.1.3 N-Gain score analysis based on PSA indicators
The average score of students' problem solving ability test based on the aspects of PSA indicators obtained from the pretest and posttest scores are presented in Table 3.

Table 3. PSA Analysis based on Indicators

PSA Indicators	Pretest	Posttest	N-Gain	Category
Problem Description	53.6	78.4	0.53	Moderate
Physics Approach	35.2	68	0.51	Moderate
Specific Physics Application	21.2	64	0.54	Moderate
Mthematical Procedure	30	52	0.31	Moderate
Logical Development	13.2	52	0.45	Moderate

Overall the problem solving ability experienced by students on each indicator has a moderate increase, and it is seen that the N-Gain value on each indicator has a value that is insignificantly different. The reason is because students feel that each stage of the PSA is not easy to solve, and because students have not done problem solving often. The reason for the low PSA is that students who answer the posttest questions do not explain the answers in detail, causing many students to lose scores. This is in line with the results of Hastuti's research that the cause of students' incorrect answers is due to lack of question practices, student accuracy, and understanding in solving the questions [18].

3.2.2 Normality test
To find out whether or not the distribution of the data obtained is normal, a normality test was performed, with the results shown in Table 4.

Table 4. Normality Test Analysis

	Pretest	Posttest	Hyphotesis Test
N	32	32	
χ^2_{count}	2,906	9,013	
χ^2_{table}	11,07	11,07	T-test
Result	$\chi^2_{count}<\chi^2_{table}$	$\chi^2_{count}<\chi^2_{table}$	
Criteria	Normal	Normal	

Table 4 shows that the data obtained from pretest dan posttest have $\chi^2_{count}<\chi^2_{table}$. Therefore, both of the data are distributed normally, and a hyphotesis test was performed using t-test.

3.2.3 Hyphotesis Test
To find out the improvement of PSA after learning process conducted, hyphotesis test was conducted using paired sample of t-test. The hypothesis in the research conducted is that there is an increase in PSA experienced by students through the simple harmonic motion experiment based on the accelerometer sensor on an smartphone. The results of processing the hypothesis test are shown in Table 5.

Table 5. Hypothesis Test Result

Scale	Numbers
M_d	32,7063
$\sum d^2$	37651
$\left(\sum d\right)^2$	1095371,51
N	32
n-1	31
N(n-1)	992
t_{count}	17,61
t_{table}	2,04227
A	5%
Total	$t_{count}> t_{table}$
Notes	H_o rejected, H_a accepted

The scale of t_{count} (17,61) > t_{table} (2,042) shows that there is an increase in PSA experienced by students through the accelerometer sensor based GHS trial on an smartphone. This increase occurs because problem-based learning was done repeatedly, so the students can practice the problem-solving abilities. By frequently training students in the problem solving stage, students' ability is improved [19]. Another factor influencing the increase in PSA in this study is the use of accelerometer sensors to support learning to be more meaningful. A meaningful learning given to students can change learning outcomes to be better [20]. During this time students rarely conduct experiments due to limited facilities at school. However, the accelerometer sensor on smartphones owned by students can train them to hone their problem solving skills. Problem-solving skills improves learning and can helps students in knowledge contruction and reasoning skills. Students can use the ability to apply problem-solving skills when faced with issues or problems that are new to them [21]. Student changes from a passive recipient of information to a participant in the creation of understanding [22]. Problem-solving is an important skill student must have when they start life after graduation [23].

3.3 Students' responses

Students' responses were obtained through questionnaires. There are three aspects obtained by distributing questuonnaire sheets, and also three aspects that are reviewed to see students' responses; the problem-solving abilities of the students, the use of the accelerometer sensor on an smartphone, and the effect of using the accelerometer sensor in learning. Based on the results obtained, 75% of students agreed that they could solve the problem solving on the SHM material, 58.1% of students agreed that the accelerometer sensor was easy to use in conducting the SHM experiment, and as many as 75% of students agreed that accelerometer sensor has a positive influence on learning physics. Overall, students responded positively to the learning proceess with a percentage of 69.4%, as shown in Figure 2.
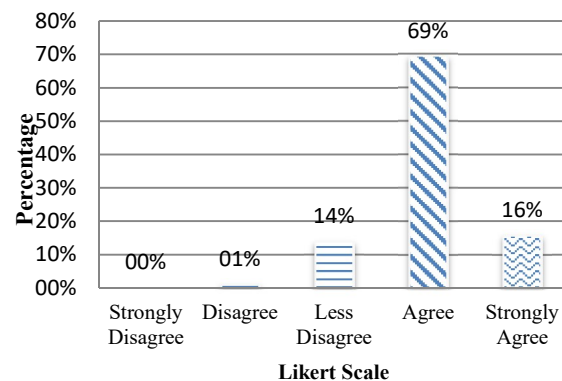
Figure 2. Students' responses percentage

4. Conclusion

Experimental activities using the accelerometer sensor on an smartphone can improve students' problem solving abilities. Although the increase was insignificant, students responded positively to this experimental activity to help increase students' problem solving abilities. Utilization of the accelerometer sensor on an smartphone can replace limited laboratory facilities, so that students can still get learning about SHM properly by using equipment owned by students.

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