AN EFFECTIVE OF POGIL WITH VIRTUAL LABORATORY IN IMPROVING SCIENCE PROCESS SKILLS AND ATTITUDES: SIMPLE HARMONIC MOTION CONCEPT

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Abstract
Simple harmonic motion is a concept that often involve complex and difficult equations, so that students can’t construct knowledge of the concept. This research applies POGIL with a virtual laboratory, where students are encouraged to construct the concept and emphasize collaborative learning with different roles. Virtual laboratory allows students to explore and establish students’ science process skills and attitude. This study used a quasi experiment with nonequivalent control group design. Therefore, this study has add to the practical knowledge to develop science process skills and establish a positive attitudes of students toward science.

Keywords: POGIL; Virtual Laboratory; Science Process Skills; Scientific Attitude; Simple Harmonic Motion

INTRODUCTION
Simple harmonic motion is a difficult concept for students to understand because it often involves a complex equation (Kareth, Dahlan, and Akbar 2018)(Obafemi and Onwioduokit 2013)(Iradat and Alatas 2017). Students are shy away from mathematical analysis of the concept, includes period, frequency, amplitude, velocity and acceleration of simple harmonic motion (Adolphus, Alamina, and Aderonmu 2013).

Simple harmonic motion can be observed using a spring and simple pendulum. This motion is a type of periodic motion or oscillation motion where the restoring force is directly proportional to the displacement and acts in the direction opposite to the displacement (Gowri, Deepika, and Krithika 2017). The spring that is stretched or compress around the equilibrium position is proportional to the force applied by force following Hooke's law, is given by (1):

\[ F = -kx \]  

Where k is a spring elastic constant and the measure x displacement of the equilibrium position (Gowri, Deepika, and Krithika 2017).
Spring period is affected by the spring constant \((k)\) and mass \((m)\), The pendulum’s period is given by (2): \((\text{Musik} 2017)\)

\[
T = 2\pi \sqrt{\frac{m}{k}}
\]  

(2)

A pendulum with a length of rope \(l\) and the mass \(m\) that is fixed rotating at the pivot point \((\text{Torzo and Peranzoni} 2015)\). The period of motion is given by: \((\text{Neto} 2017)\).

\[
T = 2\pi \sqrt{\frac{l}{g}}
\]  

(3)

Where \(g\) is the acceleration of gravity \((\text{Neto} 2017)\).

A system which exhibits simple harmonic motion of amplitude \((A)\), the position is given by the following equation: \((\text{Khotimah, Haris, and Viridi} 2015)\)

\[
vx(t) = A\omega \cos \omega t
\]

Velocity equation in simple harmonic motion is given as follows: \((\text{Gowri, Deepika, and Krithika} 2017)\)

\[
vx(t) = A\omega \cos \omega t
\]

Acceleration equation in simple harmonic motion is given by the following: \((\text{Khotimah, Haris, and Viridi} 2015)\)

\[
ax(t) = -A\omega^2 \sin \omega t
\]

Simple harmonic motion does not require to decline that complicated equation as on kinematics motion. So that the delivery of the chapter can be implemented in a balanced between physical and mathematical analysis \((\text{Khowatim, Mahardika, and Harijanto} 2017)\). Students having difficulty to understand the concept \((\text{Kareth, Dahlan, and Akbar} 2018)\)\((\text{Obafemi and Onwioduokit} 2013)\) \((\text{Iradat and Alatas} 2017)\), due to students not actively construct knowledge in their own mind \((\text{Obafemi and Onwioudokit} 2013)\) to build his own knowledge required skills, include science process skills \((\text{Ilmi, Desnita, Handoko, and Zelda} 2016)\). While the facts of physics learning activities has not been optimally trained the students’ process skills \((\text{Ramayanti, Utari, and Puzaman} 2017)\), as evidenced by the students’ science process skills is low \((\text{Irwanto, Rohaeti, Widjajanti, and Suyanta} 2017)\)\((\text{Rahayu, Pratiwi, and Indana} 2018)\)\((\text{Sukarno, Permanasari, and Hamidah} 2013)\). Lack of discovery learning makes students' science process skills is low \((\text{Lati, Supasorn, and Promarak} 2012)\). Teachers focus on the cognitive learning and rarely guide students by acquiring their skills \((\text{Rauf, Rasul, Mansor, Othman, and Lyndon} 2013)\). It's important to develop science process skills to ensure that students master the concepts taught well \((\text{Sukarno, Permanasari, and Hamidah} 2013)\). The skills needed for students to solve problems in the real life situation \((\text{Siahaan, Suryani, Kaniawati, Suhendi, and Samsudin} 2017)\). Science process skills include measuring, classifying, interpreting, predicting, hypothesizing, communicating, applying concept, planning experiments, and inferring \((\text{Irwanto, Rohaeti, Widjajanti, and Suyanta} 2017)\)\((\text{Zeidan and Jayosi} 2014)\)\((\text{Suartini, Alatas, and Sukmawati} 2014)\). Students build concept through scientific processes, then formed students’ scientific attitudes \((\text{Putra, Abdurrahman, and Suana} 2015)\).

Based on the problems mentioned above, it takes a didactic design involves students’ opportunity to build knowledge, develop concepts and process skills that Process-Oriented, Guided-Inquiry Learning (POGIL) model is designed \((\text{Chase, Pakhira, and Stains} 2013)\). POGIL is a student-centered constructivist approach \((\text{Stanford, Moon, Towns, and Cole} 2016)\), involves students’ developing their conceptual understanding collaboratively \((\text{Chase, Pakhira, and Stains} 2013)\). Characteristics of POGIL use of the learning cycle (exploration, concept invention, and application) \((\text{Hanson} 2006)\)\((\text{Rege, Havaldar, and Shaikh} 2016)\), another possibility for the development of students’ process skill \((\text{Sen, Yilmaz, and Geban} 2016)\). Developing skills and process skills influencing the process of learning are very important in POGIL \((\text{Sen and Yilmaz} 2015)\). Specific roles are also assigned to the members of a group as follows the manager, recorder, spokesperson, and strategy analyst \((\text{De Gale and Boiselle} 2015)\) to support the team building process and to encourage the students participation and responsibility \((\text{Rege, Havaldar, and Suyaikh} 2016)\). The teacher teaches the content and process skills simultaneously \((\text{Sen and Yilmaz} 2015)\). Learning process provides students
opportunities to develop (Walker and Warfa 2017), and improve a scientific attitude during science content learning (Aktamis and Ergin 2008).

Most POGIL studies were carried out either over a long period of time (De Gale and Boisselle 2015)(Chase, Pakhira, and Stain 2013). That’s good by using software simulation to better exploring the concept (Kahar, Esa, Tay, Hashim, Laham, and Wong 2016). One of them, that virtual laboratory enhance students' inquiries skills (Ranjan 2015), implementing time-consuming experiments and feedback in a shorter period of time (Gulsum and Didem 2017), in order to increase the effectiveness of learning (Sarı, Hassan, Guven, and Sen 2017). Virtual laboratory used were Phet simulation Colorado. Based on the explanation above, this study aims to apply the POGIL with Phet simulation Colorado in simple harmonic motion learning, and determine its effect on students’ science process skills and attitude. The attitude of studied was attitude after learning, attention in students’ academic ability.

METHOD

This study was conducted in MAN 3 Jakarta, with a total of 29 students, consisting of 8 male students and 21 female students. Characteristics of students were stratified into three academic ability goups, 7 of the students taught in highest academic ability, 13 in middle academic ability and 9 in low academic ability either the control or experimental group. Samples are students of class X IPA 1 as the control group and X IPA 2 as the experimental group.

This study used a quasi experiment (Pardimin and Arcana 2018), with nonequivalent control group design (Sugiyono 2015). Sampling technique is purposive sampling (Sarstedt, Bengart, Shaltoni, and Lehmann 2018). Instruments used to obtain data are science process skills tests, science process skills observation sheets and scientific attitude questionnaires. Science process skills tests include observing, classifying, interpreting, predicting, communicating, applying concept, planning experiments. Data were analyzed by using the N-Gain test on equation 1 (Coletta and Phillips 2005).

\[
N - \text{Gain} = \frac{\text{posttest} - \text{pretest}}{\text{pretest}}
\]  

(1)

Interpretation of N-Gain was 0 < G < 0.3 low category, 0.3 ≤ G < 0.7 middle category, and 0.7 < G high category (Hake 1998). Prerequisites test using normality (Kolmogorov-Smornov) and homogeneity test (Levene test). Hypothesis test using T test with 5% level of significance (α = 0.05).

Attributes of scientific attitudes are curiosity, discovery and creativity, open-mindedness and cooperation, respect the data, critical thinking, perseverance, and respect for another’s point of view. Data percentage is calculated using the following formula:

\[
\text{Percentage} = \frac{\text{score}}{\text{maximum score}} \times 100\%
\]

(Wiwin and Kustijono, 2018)

Determinants of scientific attitude criteria is very good (86-100%), good (76% - 85%), fair (60% - 75%), less (55% - 59%) and poor (≤ 54%). (Purwanto 2006).

RESULT AND DISCUSSION

Science Process Skills

Science process skills include observing (C1), classifying (C2), interpreting (C3), predicting (C4), communicating (C5), applying concepts (C6), planning experiments (C7). Instruments test using multiple-choice test. Improved science process skills were tested using N-Gain based on a student’s academic ability groups. The calculation results are presented in Table 1.

Table 1 shows the N-Gain results of science process skills based on students’ academic ability. Students’ high academic ability in control and experiment group had middle category. Students’ middle and low academic ability in control group had low category, while the experimental group had middle category. In POGIL, students are engaged in learning. Students understand to the phenomena observed, then collect the facts in the observation, summarize the results of the experiment, explained the results of the experiment, and connect these observations with the existing theory (Zamista and Kaniawati 2015). POGIL makes students trained to conclude data analysis (Umam and Subiki 2013).
Before hypothesis testing, first is prerequisite test used normality and homogeneity test. Prerequisite test used normality test with (α) = 0.05 level of significance. Here is a prerequisite results in the study. Normality test used Kolmogorov-Smornov. The result of pretest and posttest normality on students’ academic ability group as can be seen in Table 2.

Based on table 2, the significant result of pretest and posttest experiment and control group, for the low, middle, and high academic ability group is greater than the level of significance (α) or 0.05, it can be concluded that pretest and posttest results of experiment and control group on each student's academic ability groups entirely normal distribution.

Homogeneity results of pretest and posttest based on students' academic ability group as can be seen in Table 3.

Based on table 3, the significant result of pretest and posttest experiment and control group, for the low, middle, or high academic ability is greater than the level of significance (α) or 0.05, it can be concluded that the pretest and posttest results of experiment and control group on each academic ability were homogeneous.

### Table 1. N-Gain Student Science Process Skills

<table>
<thead>
<tr>
<th>Aspects of SPS</th>
<th>Low Academic Ability</th>
<th>Middle Academic Ability</th>
<th>High Academic Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Experiment</td>
<td>Control</td>
</tr>
<tr>
<td>C1</td>
<td>0.16</td>
<td>0.44</td>
<td>0.15</td>
</tr>
<tr>
<td>C2</td>
<td>0.07</td>
<td>0.33</td>
<td>0.05</td>
</tr>
<tr>
<td>C3</td>
<td>0.12</td>
<td>0.46</td>
<td>0.11</td>
</tr>
<tr>
<td>C4</td>
<td>0.06</td>
<td>0.31</td>
<td>0.04</td>
</tr>
<tr>
<td>C5</td>
<td>0.14</td>
<td>0.43</td>
<td>0.12</td>
</tr>
<tr>
<td>C6</td>
<td>0.13</td>
<td>0.36</td>
<td>0.13</td>
</tr>
<tr>
<td>C7</td>
<td>0.05</td>
<td>0.37</td>
<td>0.03</td>
</tr>
<tr>
<td>Average</td>
<td>0.09</td>
<td>0.38</td>
<td>0.10</td>
</tr>
<tr>
<td>Category</td>
<td>Low</td>
<td>Middle</td>
<td>Low</td>
</tr>
</tbody>
</table>

### Table 2. Pretest and Posttest Normality Test

<table>
<thead>
<tr>
<th>Group</th>
<th>Academic ability</th>
<th>Test</th>
<th>Statistical</th>
<th>Signification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>Low</td>
<td>Pretest</td>
<td>0.255</td>
<td>0.187</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>0.255</td>
<td>0.187</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>Pretest</td>
<td>0.267</td>
<td>0.140</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>0.270</td>
<td>0.133</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Pretest</td>
<td>0.255</td>
<td>0.187</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>0.256</td>
<td>0.182</td>
<td>Normal</td>
</tr>
<tr>
<td>Control</td>
<td>Low</td>
<td>Pretest</td>
<td>0.205</td>
<td>0.200</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>0.152</td>
<td>0.200</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>Pretest</td>
<td>0.222</td>
<td>0.200</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>0.263</td>
<td>0.109</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Pretest</td>
<td>0.222</td>
<td>0.200</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Posttest</td>
<td>0.196</td>
<td>0.200</td>
<td>Normal</td>
</tr>
</tbody>
</table>

### Table 3. Pretest and Posttest Homogenity Test

<table>
<thead>
<tr>
<th>Academic Ability Group</th>
<th>Test</th>
<th>Statistical</th>
<th>Signification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Pretest</td>
<td>0.078</td>
<td>0.926</td>
<td>Homogen</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>4.667</td>
<td>0.052</td>
<td>Homogen</td>
</tr>
<tr>
<td>Middle</td>
<td>Pretest</td>
<td>9.600</td>
<td>0.053</td>
<td>Homogen</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>5.000</td>
<td>0.053</td>
<td>Homogen</td>
</tr>
<tr>
<td>High</td>
<td>Pretest</td>
<td>0.000</td>
<td>1.000</td>
<td>Homogen</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>0.400</td>
<td>0.561</td>
<td>Homogen</td>
</tr>
</tbody>
</table>

### Table 4. Pretest and Posttest Hypothesis Test

<table>
<thead>
<tr>
<th>Academic Ability Group</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Signification</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>Signification</td>
<td>0.00</td>
</tr>
<tr>
<td>Middle</td>
<td>Signification</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Signification</td>
<td>0.00</td>
</tr>
<tr>
<td>High</td>
<td>Signification</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>Signification</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Table 5. Relationship POGIL, Science Process Skills, Scientific Attitude, Cognitive Ability, and Simple Harmonic Motion Concept

<table>
<thead>
<tr>
<th>POGIL</th>
<th>Science Process Skills</th>
<th>Scientific Attitude</th>
<th>Cognitive Ability</th>
<th>Simple Harmonic Motion Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>Observation</td>
<td>Curiosity</td>
<td>Identification (C1)</td>
<td>Students are provided a video of the shock absorber motorcycle through the streets of hollow driven by one person and two people.</td>
</tr>
<tr>
<td>Exploration</td>
<td>Prediction</td>
<td>Discovery and creativity</td>
<td>Foreseeing (C3)</td>
<td>Students make hypotheses based on observations of the video above, perform a simple experiment using PhET and fill a test in each group by a reporter.</td>
</tr>
<tr>
<td>Plan experiment</td>
<td>Hypothesize</td>
<td>Open-mindedness and cooperation</td>
<td>Implementation (C3)</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Communication</td>
<td>Respect the data</td>
<td>Analyze (C4)</td>
<td></td>
</tr>
<tr>
<td>Concept Form</td>
<td>Interpretation</td>
<td>Critical thinking</td>
<td>Analyze (C4)</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Communication</td>
<td>Perseverance</td>
<td>Implementation (C3)</td>
<td>Students apply the concepts to new situations.</td>
</tr>
<tr>
<td>Application</td>
<td>Apply the concept</td>
<td></td>
<td>Apply (C3)</td>
<td></td>
</tr>
<tr>
<td>Closure</td>
<td>Communication</td>
<td>Respect for another’s point of view</td>
<td>Summerize (C2)</td>
<td>Student learning outcomes and concludes with the teacher to reflect on the learning.</td>
</tr>
</tbody>
</table>

An explanation of the relationship between POGIL, science process skills, scientific aspects, cognitive ability, and simple harmonic motion concept presented in Table 5.

Table 5 illustrates the relationship between POGIL, science process skills, cognitive ability, and simple harmonic motion concept. Cognitive abilities in C1 (remembering), C2 (understanding), C3 (applying), and C4 (analyzing) associated with science process skills, POGIL, and simple harmonic motion concept. Study suggested that the use of POGIL impact on students to a better understanding and contribute to enhance grades and retention (Chase, Pakhira, and Stains 2013).

Scientific Attitude

The results of data analysis questionnaire students’ scientific attitude are shown in Table 6.

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Table 6 shows that the students' scientific attitude of the high academic ability group (86.51%) categorized very well. Scientific attitude related to the students' science process skills.

Students’ science process skills who have a scientific attitude above the average is better than students’ science process skills who have a scientific attitude below average (Hannasari, Harahap, and Sinulingga 2017). The majority of students have a positive impression on POGIL, students would prefer a POGIL learning, that help students cultivate a positive attitude toward learning, and change the perception of students towards subjects that are considered difficult. Student give a positive response to learning POGIL because it can improve students’ performance (Sen, Yilmaz, and Geban 2016).

CONCLUSION

The use of POGIL with virtual laboratory had an advantage for students’ science process skills in low, middle and high academic ability. POGIL help to increase students’ science process skills, evidenced by increasing ability the process of science in middle category. Aspects of performance skills are developed: to observe, classify, interpret, predict, communicate, implement the concept, plan the experiments. Both model, POGIL with virtual lab help students to float the students’ scientific attitude. Based on this, POGIL with virtual laboratory has a positive impact on science process skills and students’ scientific attitude.

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