The Effectiveness of the POGIL Learning Model on Simple Harmonic Motion Topic to Enhance Students' Science Process Skills

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Abstract

The lack of training in students' science process skills indicators in physics subjects has resulted in a majority of students in one of the high schools in Banjarmasin, grade X MIPA, having relatively low science process skills. This study aims to describe the effectiveness of the POGIL learning model and assess the achievement of students' science process skills. This study used a one-group pretest-posttest design. The results showed that using the POGIL model based on the n-gain calculation had a high effectiveness category with a value of 0.73 and trained students' science process skills, as indicated by an increase in the achievement of science process skills, which had a very good category. Based on these results, using the POGIL model can provide benefits in practicing students' science process skills.

Keywords: POGIL learning model, science process skills, simple harmonic motion

How to cite: Rahmi, N. A., Mastuang, M., & Dewantara, D. (2024). The effectiveness of pogil learning model on simple harmonic motion topic to enhance students' science process skills. *Jurnal Ilmiah Pendidikan Fisika*, *8*(1), 34-43.

INTRODUCTION

Based on national education goals and local regulations regarding the implementation of education, teachers, and students play a significant role in the learning process. The essence of education in each subject lies in the learning process, which aims to improve each student's behavior and develop their potential (Kirom, 2017; Rusman, 2017). Educators and students are expected to actively apply competency-based learning and emphasize process skills using a scientific approach (Kemendikbud, 2016). Students' success in physics learning is determined by the understanding of concepts achieved, as physics learning requires critical thinking skills (Abdullah et al., 2021; Ansori et al., 2019). Basic skills, especially in physics learning, often used by scientists to acquire scientific knowledge, are called process skills. Process skills in this context are seen as an approach to teaching physics concepts involving cognitive skills and investigative understanding of students, serving as a reference for educators to emphasize students' skills in order to acquire and communicate the concepts learned by
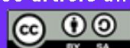
students (Dahlia et al., 2019; Nurtang & Haris, 2019). Skills that focus on the learning process and thinking skills to process information, understand concepts, solve various problems, and develop independent facts are called science process skills (Darmaji et al., 2019; Kane et al., 2016).

Based on the initial observations on science process skills, issues were found in class X at SMA Negeri Banjarmasin, indicating that the science process skills were categorized as low. Only 22.85% were able to formulate problems, 11.42% could formulate hypotheses, 22.85% could identify variables, 8.57% could define operational variables, 14.28% could analyze data, and 5.71% could conclude. This is supported by the characteristics of students, especially in physics learning, who only study from books, focus on physics formulas, are not trained in indicators of science process skills, and rarely conduct practical activities.

An alternative solution used to address the problems that arise is to train science process skills using a suitable and appropriate learning model. The Process Oriented Guided Inquiry Learning (POGIL) model is considered capable of improving science process skills. POGIL is an inquiry-based learning model that combines inquiry strategies and process skills with cooperative learning (Mellyzar et al., 2022; Şen et al., 2015). The learning process using the POGIL model focuses on the scientific process of acquiring concepts and aims to enhance student's understanding through critical thinking and analysis, guiding students through structured activities that direct their thinking and reasoning (Rumain & Geliebter, 2020; Sudartik et al., 2023). POGIL emphasizes content, knowledge structure, and process components, which involve how students can obtain, apply, produce, and construct knowledge. This guides students to actively participate, think, and

collaborate with their group to understand concepts and develop thinking skills (Putri et al., 2020; Saraswati et al., 2018). Implementing the POGIL model focuses on process skills, thus relating to students' understanding and development of process skills, especially science process skills (Geiger, 2010; Rustam & Setijani, 2017). POGIL is a research-based learning methodology based on the latest understanding of how students learn best (Aiman et al., 2020; Moog & Spencer, 2008).

Learning in the classroom using the POGIL model is conducted by guiding students and playing a role in activating science process skills through the understanding of concepts built through concept investigation, making collaborative and meaningful learning for students (Andriani et al., 2019; Oktaria et al., 2023). One of the high school physics topics is simple harmonic motion, which discusses harmonic vibrations. In learning harmonic motion, students are not only required to master knowledge but also demanded to master process skills. In this topic, finding information and understanding concepts can involve science process skills (Rahmadanty & Wasis, 2020). The simple harmonic motion material can be collaborated with the POGIL model because the learning objectives for this material are oriented towards process skills. Moreover, the subject of physics essentially involves physics as a process. The collaboration between the POGIL model and the simple harmonic motion material is beneficial. This model can train students' science process skills and is student-centered, allowing students to build their abilities during the process (Zamista, 2016).

Fachrunisa's (2018) research on the collaboration of simple harmonic motion material with the POGIL model shows an impact on improving students' science process skills. Hence, the POGIL model is considered helpful in training science

process skills. Relevant studies using the POGIL model to train students' science process skills have also been conducted by Dionisius et al. (2019), indicating differences in science process skills between groups taught with conventional learning models and those taught using the POGIL model, with significant improvements in the latter. Similar research was conducted by Karimah & Nurita (2020) on implementing POGIL learning, showing an increase in science process skills after applying the POGIL model. Another study by Ghaida et al (2021) found that applying the POGIL model through the ARCS strategy improved students' science process skills from a very low category to a skilled category. In this study, the stages of learning using the POGIL model, aimed at training science process skills, are combined with strengthening the character "kayuh baimbai" (rowing together) and creating a learning outcome test based on the formation of concepts obtained by students during the practicum. Based on this background, the aim is to describe the effectiveness of implementing the POGIL learning model to train students' science process skills, focusing on simple harmonic motion.

METHOD

The research was conducted in the second semester of the 2022/2023 academic year, involving tenth-grade science students (X MIPA) in one of the high schools in Banjarmasin. The research sample consisted of 35 students. This study used a Pre-Experimental design with a one-group pretest-posttest trial, where one group of participants was observed after a treatment believed to cause changes (Ali Bin-Hady et al., 2020; Arikunto, 2016; Sugiyono, 2009).

Table 1 One group pretest-posttest design

Pretest	Treatment	Posttest
O_1	X	O_2

Information:

O_1 = Initial test before treatment

X = Learning with the POGIL model

O_2 = Final test after treatment

The data collection technique for effectiveness was based on students' achievement through learning outcome test results. The data analysis technique for the effectiveness of the research treatment on students' abilities was calculated using n-gain. The criteria of the n-gain score can be seen in Table 2.

Table 2 Criteria of the obtained score

Range	Category
$\langle g \rangle > 0,7$	High
$0,3 \leq \langle g \rangle \ 0,7$	Medium
$\langle g \rangle < 0,3$	Low

(Hake, 1998)

Additional effectiveness testing required hypothesis testing with a paired sample t-test with hypotheses:

− H_0: There is no significant difference in students' abilities before and after the treatment.

− H_1: There is a significant difference in students' abilities before and after the treatment.

Another effectiveness test is the Effect Size test, which measures how much one variable influences another variable (Cohen et al., 2018; Huck, 2012). The criteria for obtaining effect size can be seen in Table 3.

Table 3 Criteria for obtaining the Effect Size (ES)

ES	Category
$0,2 \leq ES < 0,5$	Small
$0,5 \leq ES < 0,8$	Medium
$0,8 \leq ES < 1,3$	Big
$ES \geq 1,3$	Very Big

(Rahmandani et al., 2022)

Students' achievements were described based on the assessment of improvement in each indicator during the completion of worksheets with a specific assessment rubric. The criteria for obtaining scores for science process skills can be seen in Table 4.

Table 4 Criteria for assessing science process skills

SPS Score	Category
X > 3,4	Very Good
2,8 < X ≤ 3,4	Good
2,2 < X ≤ 2,8	Medium
1,6 < X ≤ 2,2	Low
X > 1,6	Very Low

(Widoyoko, 2017)

RESULTS AND DISCUSSION
The POGIL learning model was implemented in five phases: orientation, exploration, concept formation, application, and closure (Arsy & Octarya, 2022; Hanson, 2007). Learning using the POGIL model in this research was conducted in three meetings with subtopics consisting of pendulum swings, spring vibrations, and quantities in simple harmonic motion.

In general, students' activities during the introduction and orientation phases involved presenting a problem situation to students related to the experiment to be conducted. The core activity in the exploration phase involved the teacher guiding students to understand the completion of worksheets, the need for experimental tools and materials, and answering each worksheet question, including formulating problems, formulating hypotheses, identifying variables, and defining operational variables. The core activity in the concept formation phase involved students conducting experiments, analyzing data, and drawing conclusions. The core activity in the concept application phase involved students solving problems based on the newly acquired concepts, and then group representatives presented their results. The teacher explained the material and its relevance to life to strengthen concept understanding, with the aim of training science process skills. Putri (2019) stated that scientific skills related to how knowledge is acquired and how someone thinks, enabling them to formulate concepts, facts, principles, and laws relevant to objects in scientific events, are interpreted as science process skills.

Effectiveness
The effectiveness of the POGIL model can be assessed through students' learning outcome test scores (THB). THB serves as a measure to determine students' success in the educational program, involving both pretest and posttest phases to assess students' initial knowledge at the beginning of learning and their competency achievement afterward (Sani et al., 2020).

Table 5 Proportion of student score achievements

No.	Learning Objectives	The proportion of Student Learning Outcome Scores	
		Pretest	Posttest
1	Formulate the period/frequency of simple pendulum swings/spring vibrations.	0,03	0,34
2	Calculate the frequency of simple pendulum swings.	0,15	0,78
3	Calculate spring vibrations.	0,12	0,85
4	Calculate the potential, kinetic, and mechanical energy of simple harmonic motion.	0,02	0,96

Based on the research results, during the pretest, with a school-set Minimum Mastery Criteria (MMC) of 70, it was found that no student was able to achieve the MMC. The number of students who met the MMC was 26, while those who did not meet the MMC were 9. The difference in learning outcomes is due to several factors, including internal factors such as physiological and psychological

aspects and external factors such as school/family/community environment (Ravena & Sholih, 2022).

Question 1 is a C4 level question, requiring students to analyze and conclude a problem from an experiment whose data has been provided. The results showed that students were unable to answer question 1 with a maximum score, and some students did not provide an answer. Questions 2 and 3 revealed that most students could answer correctly, with shortcomings only in specifying known and queried variables. However, a small number of students were unable to complete the questions. Question 4 is a C4 level question, and the results showed that some students could answer correctly, with shortcomings only in specifying variables and the inaccuracy of students.

The proportion of students' learning outcome scores can be seen in Table 4. The average pretest and posttest results and the n-gain calculation, can be seen in Table 6.

Table 6 Effectiveness calculation results

Pretest	Posttest	N-gain	Category
7.02	75.02	0.73	High

Based on the data in Table 6, it can be seen that the students' pretest results are very low, with an average pretest score of 7.02. During the pretest, several factors contributed to the very low scores, such as students only being able to write down known and queried information and some questions receiving no score because they were left unanswered. The average post-test score was 75.02, indicating an improvement in student learning. The resulting n-gain,

with a value of 0.73, falls into the high category.

The significant difference between pretest and posttest scores can be observed by conducting a paired sample t-test. The test results yielded a value of 32.31 with a p-value of 0.00, indicating a significant difference in students' abilities before and after the treatment.

The effectiveness of using the POGIL model in learning to train critical thinking skills can be calculated using effect size eta squared for paired sample t-test (η^2) as follows.

$$\eta^2 = \frac{32,31^2}{32,31^2 + (35-1)} = 0,968$$

Based on Table 3, the research falls into the large category. It is found that students' learning outcomes can be enhanced using the POGIL model, aligning with the research by Dani & Qurana (2022), stating that the understanding of physics concepts can be efficiently improved using the POGIL model.

Achievement of Science Process Skills (SPS)

The achievement of students' SPS can be assessed and analyzed using observation sheets during the inquiry learning activities (Marisyah et al., 2016). The measurement of students' SPS involves observations by three people using worksheets. The observed SPS indicators include six indicators, namely formulating problems (M_1), formulating hypotheses (M_2), identifying variables (M_3), defining operational variables (M_4), analyzing data ($M_5$5), and concluding (M_6). The results of KPS achievement per indicator can be seen in Table 7.

Table 7 Results of SPS on each indicator

SPS Indicator	Meeting 1		Meeting 2	
	Average	Information	Average	Information
1	3.20	B	4.00	SB
2	3.67	SB	3.73	SB
3	3.60	KB	4.00	SB
4	2.13	KB	4.00	SB

SPS Indicator	Meeting 1		Meeting 2	
	Average	Information	Average	Information
5	4.00	SB	4.00	SB
6	3.40	B	3.87	SB
Average of each meeting	3.33	B	3.93	SB

Based on Table 7, the first meeting found that the science process skill indicator of defining operational variables had the lowest score compared to other indicators. Students had difficulty defining operational variables in the experiment and did not align with the indicator when creating the Definition of Variables (DOV). In creating DOV, students should study the experimental plan to help test hypotheses, define variables, and write clear definitions of how to measure variables and control variables (Suyidno, 2020). In the second meeting, the hypothesis formulation indicator had the lowest score compared to other science process skill indicators.

Based on Table 7, the category of students' science process skills was good in each meeting, and there was an improvement. Before applying to learn using the POGIL model, the student's initial ability was in the less category, and this achievement showed an improvement in the skill category to excellent. Based on the research conducted by Setyaning & Rosdiana (2017), a pass rate of 74.28% was obtained with a high n-gain value of 0.73 after applying the POGIL model with learning outcomes to measure process skills.

The indicators of science process skills showed improvement in each indicator, consistent with Hombing et al. (2017), stating that learning involving skills-related exercises can make students accustomed to science process skills and understand concepts through experiments. The improvement in students' learning outcomes occurred because of the knowledge acquired and repeated learning over a considerable period (Elnada et al., 2016). Selain itu,

Rahmatillah et al. (2017) stated that worksheets containing guidance for science process skill activities were deemed to enhance these skills, allowing students to acquire new knowledge and skills. This is supported by Mahjatia et al. (2021), who found that using worksheets with a guided inquiry model was effective in training students' science process skills. It can be concluded that the use of developed worksheets effectively trains students' science process skills.

The POGIL stages include orientation, exploration, concept formation, application, and closure (Arsy & Octarya, 2022; Hanson, 2007). The POGIL stages in this study began with the orientation stage, where the teacher presented a problem situation and provided motivation at the beginning of the learning process to stimulate students' attention. The second stage was exploration, where the teacher formed students into groups, distributed worksheets, and guided the groups to formulate hypotheses, identify variables, and define operational variables. The third stage was concept formation, guiding students in conducting experiments, analyzing data, and drawing conclusions. The fourth stage was application, where the teacher directed students to solve problems based on their conceptual knowledge, and group representatives presented their work. The fifth stage was closure, involving a question-and-answer session between the teacher and students to reflect on the problem-solving discussed at the start of the learning process.

CONCLUSION
The results of applying the POGIL learning model on simple harmonic

motion to train science process skills have proven effective. This is evident from the learning outcomes, with a high n-gain value of 0.73, and the achievement of science process skills observed through the SPS observation sheet, which falls into the excellent category. The hope for this research outcome is to inform readers as a consideration and contribute thoughts for further POGIL-related research.

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