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Profile of Science Process Skills in Class XI Learners in the Implementation of the POGIL Model on Static Fluid Material

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Abstract

The lack of experimental methods in physics learning causes students in one of the public high schools in Banjarmasin City to have low scores for science process skills (SPS). The teacher's results also corroborate this needs analysis, which shows the need to implement learning that supports the development of SPS. Therefore, the purpose of this study is to describe the SPS profile of students through the implementation of the POGIL model. The research method is categorized as quantitative research using a pre-experimental design. Data collection techniques regarding the SPS profile of students were carried out using the SPS observation sheet instrument by observers. The data analysis technique used was descriptive quantitative. The average achievement results for each SPS indicator are as follows: formulating problems 98.61; formulating hypotheses 93.52; identifying variables 57.41; conducting experiments 82.41; analyzing data 91.20; and drawing conclusions 74.54. Based on the results of this study, implementing the POGIL model is effective in training students' SPS. Overall, the study showed that the approach used improved learners' SPS and facilitated active and collaborative learning. This is highly relevant for educators and curriculum developers designing more effective learning experiences in science. Future research is expected to emphasize the SPS indicators and better organize students to play a more active role in learning activities.

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INTRODUCTION

Physics's nature is divided into 3: physics as a process, physics as an attitude, and physics as a product (Fatmawati et al., 2024; Siregar, 2021). Learning physics is closely related to experiments and practices demonstrating the occurring phenomena. Experiments and practical activities support updating various physics concepts so that process skills-based learning is needed to increase students' knowledge in the learning process. To balance the knowledge of the material obtained in the classroom, learning can be done through the process, namely in the form of science process skills (SPS) (Darmaji et al., 2019; Hanum, 2023; Rahmi et al., 2024).

SPS is a complex skill or ability commonly used by scientists to investigate a series of learning processes (Rini et al., 2022; Yuliskurniawati et al., 2019). In addition, science process skills are the ability of students to apply, understand, and develop scientific

methods to discover science. SPS is also a scientific method that involves practicing steps to conduct experiments (Darmaji et al., 2020; Hartati et al., 2022). SPS are skills that can simultaneously encourage behavior in acquiring knowledge and skills (Gunawan et al., 2019; Rini & Aldila, 2023).

SPS consists of basic skills and integrated SPS. There are six basic skill indicators: observing, classifying, communicating, measuring, predicting, and concluding. In advanced process skills, there are seven indicators: asking questions, formulating hypotheses, identifying variables, defining variables operationally, conducting experiments, analyzing experimental data, and making conclusions (Darmaji et al., 2020; Yunita & Nurita, 2021).

Initial observations were made by researchers at one of the public high schools in Banjarmasin City using a questionnaire that provided a factual picture related to the physics learning process that had taken place in the school/class. The statement indicates the concentration of attention and participation in physics learning: "In every physics lesson, the teacher always illustrates/simulation/practicum/video in explaining the material." Based on the results of the responses obtained on this statement, there has been a positive response from students, but it was very minimal in number. Teacher interviews reinforce these results, stating that the presentation of material during learning occurs so far in a one-way manner, dominated by the lecture method. Practicum or physics experiments have not been carried out optimally and are only limited to the introduction of tools and reading of measuring instruments taught in the previous semester 1. Based on this statement, it can be said that students' science process skills are less trained.

Untrained SPS will make students less able to interact and communicate with friends in the group, less able to develop scientific attitudes, less able to think critically and analytically, and make students difficulty applying science concepts in everyday life (Inayah et al., 2020; Khairunnisa, 2014). One of the subjects in physics learning that is closely related to experimental activities is static fluid. This study's selection of static fluid material is based on the complexity of concepts that require in-depth understanding and their relevance to everyday life. Static fluid material has many applications in everyday life, such as in understanding pressure in liquids, using pressure measuring instruments, and natural phenomena such as floating objects in water. By linking this material to everyday experiences, students can more easily understand and apply these concepts, thus increasing their learning motivation. Based on the previously described problems, the results show a need for a learning model to improve students' science process skills, especially in static fluid material.

Efforts to improve students' SPS are made by selecting the right learning model, especially for SPS, which has a constructivist approach and links knowledge with real experiences in everyday life. One of the learning models based on the constructivism approach is the Process Oriented Guided Inquiry Learning (POGIL) model, which emphasizes learning to work in teams, develop conceptual understanding, and develop science process skills, thinking skills, problem-solving skills, communication skills, management skills, and development skills (Mellyzar et al., 2022; Putri et al., 2020; Toyo et al., 2019).

The POGIL model is a process-oriented and learner-centered guided inquiry learning model, which is designed with small groups that interact with the instructor or teacher as a facilitator (Oktaria et al., 2023; Rahayu, 2019). The POGIL model elaborates on three components: learning teams (cooperative learning processes), guided inquiry activities, and metacognition (Haryati, 2018; Kurniasih, 2023). The POGIL model is a refinement model of guided inquiry that can facilitate the implementation of learning through inquiry learning in the classroom or laboratory (Oktaria et al., 2023; Rahayu et al., 2019).

Learning with the POGIL model prioritizes investigation in finding concepts in the learning process so that learning is centered on student-centered activities with specially

designed activities and cooperative learning to teach content actively in involving students in investigation, analytical thinking, and teamwork so that students' process and generic skills can be further developed (Nuralif & Hakim, 2023; Oktaria et al., 2023; Rumain & Geliebter, 2020). The POGIL model adopts some of the novelty of the guided inquiry model with some significant differences and improvements, including active teacher guidance, cooperative groups, constructivist learning processes, critical thinking skills, effectiveness in improving learning outcomes, and communication and metacognition skills (Mertasari, 2021; Putri et al., 2020). The POGIL model consists of 5 stages: Orientation, Exploration, Concept Formation, Application, and Closure (Edyana, 2023; Hanson, 2005; Haryati, 2018).

Previous research by Ghaida et al. (2021) found that applying the POGIL model through the ARCS strategy can improve students' SPS in the skilled category. Another study conducted by Rahmi et al. (2024) showed that the application of the POGIL model on simple harmonic motion material observed through the SPS observation sheet could improve the achievement of students' SPS in the very good category. In this study, the POGIL model was implemented using the latest curriculum, namely the independent curriculum, and SPS was emphasized in experiments to increase students' SPS. Therefore, this study aimed to describe the improvement of students' SPS as an implementation of the POGIL model.

METHODS

The research method is categorized as quantitative research using a pre-experimental design. This design is used because the research does not involve a control class but only the experimental class; this is due to the limitations of the class that has been provided and can be used at the time of research only 1 class. The treatment was given to determine the improvement of students' SPS by using the POGIL model (Thyer, 2010).

This study's test subjects were grade XI students at one of the public high schools in Banjarmasin, as many as 22 students in the even semester of 2023/2024. The material used in this study is static fluid, with the subtopics of hydrostatic pressure, Pascal's law, Archimedes' law, surface tension, capillarity, and liquid viscosity.

Before the research was carried out, the observer was briefed on how to fill in the instrument and was in accordance with the instructions on the instrument. During the research, the observer was the same person at each meeting. The instrument used is the SPS observation sheet, which is assessed by the observer and obtained from the learner worksheet (LW) answers during the learning process. The SPS observation sheet assesses 6 SPS indicators: formulating problems, formulating hypotheses, identifying variables, conducting experiments, analyzing data, and drawing conclusions on each LW. Assessment of SPS indicators through a group assessment rubric adapted to the experiment's characteristics, containing four criteria that must be met to obtain the maximum score.

The data obtained from the research is then analyzed quantitatively to describe the improvement of students' SPS. The acquisition of observation results based on the SPS observation sheet is then processed using equation (1) to determine the acquisition of students' SPS, which is then interpreted in Table 1 Suyidno et al., (2020) SPS achievement category.

Table 1 SPS achievements

Value Interval	Kategori
$80 < \text{Value} \leq 100$	Very good
$65 < \text{Value} \leq 80$	Good
$55 < \text{Value} \leq 65$	Simply
$40 < \text{Value} \leq 55$	Not good
$\text{Value} \leq 40$	Very not good

RESULT AND DISCUSSION

The improvement of students' science process skills is reviewed from the results of the SPS observation sheet filled out by the observer. This study observes the achievement of SPS indicators at an advanced level based on the results of LW answers with the observed indicators, namely formulating problems (M1), formulating hypotheses (M2), identifying variables (M3), conducting experiments (M4), analyzing data (M5), drawing conclusions (M6). 3 LWs were tested, namely LW 1 hydrostatic pressure, LW 2 Archimedes' law, and LW 3 viscosity of liquid. The achievement of SPS indicators on each LW that has been tested is presented in Table 2.

Table 2 Achievement of SPS indicators

Indicator	LW			Overall Average
	1	2	3	
M1	95.83 (VG)	100.00 (VG)	100.00 (VG)	98.61 (VG)
M2	80.56 (VG)	100.00 (VG)	100.00 (VG)	93.52 (VG)
M3	31.94 (VNG)	51.39 (NG)	88.89 (VG)	57.41 (S)
M4	76.39 (G)	84.72 (VG)	86.11 (VG)	82.41 (VG)
M5	73.61 (G)	100.00 (VG)	100.00 (VG)	91.20 (VG)
M6	69.44 (G)	66.67 (G)	87.5 (VG)	74.54 (G)

Description: VG (Very Good); G (Good); S (Simply); NG (Not Good); VNG (Very Not Good)

At each meeting, SPS's achievement on each indicator increased. M1 and M2 are indicators of formulating problems and formulating hypotheses, obtaining a significantly high value where students can answer correctly. Figure 1 is the answer to the LW of one group of students on the indicator of formulating a problem, which in English means, “How does the type of liquid (viscosity) affect the speed of a dropped marble (terminal velocity)?”

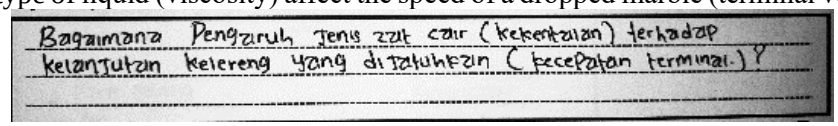

Figure 1 Problem formulation answer

Formulating problems in learning is useful for honing students' critical thinking skills towards events that exist in everyday life so that the increase that occurs in formulating problems at each meeting can make students more skilled, which is also in line with previous research with a significant increase from the initial ability of students in the very poor category to the ability to be categorized as skilled (Dewi et al., 2023; Ghaida et al., 2021).

In the exploration stage, the teacher explains the studied material and provides problems regarding examples. Based on the given issues, students process them into a problem formulation, which is then followed by formulating a hypothesis. This can improve students' observation skills because students try to develop hypotheses from the problems given by connecting the material that has been obtained (Hutagalung, 2023; Saraswati et al., 2018).

Learners who have succeeded in formulating the problem and have understood the problems and material to be tested tend to be able to process the hypothesis formulation of the experiment to be tested. This is in line with research conducted by Idrus et al. (2021), where students who have successfully observed and interpreted the problems given are able

to predict and make hypotheses from the experiment, with percentages obtained of 89.6% and 91.7%.

The third indicator (M3) is identifying variables. This indicator obtained the smallest average with a sufficient category. This can occur because students still have difficulty in determining the manipulation, response, and control variables in the experiment to be carried out. The following is the answer from the LW of one group of students on the indicator of identifying variables, which in English means "manipulation variable: volume; control variable: acceleration of gravity; response variable: weight of objects in water and air."

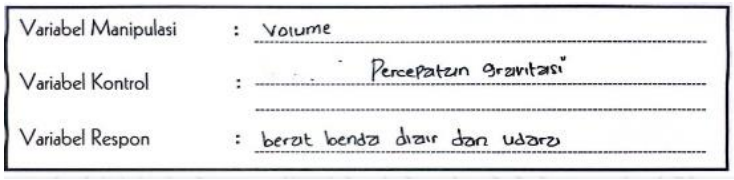

Figure 2 Answers identifying variables

This is in line with the research of Nosela et al. (2021), which states that in identifying variables, students are proficient in determining the independent and dependent variables in the experiment. However, students still have difficulty determining the control variable, so teacher guidance is needed to increase this indicator at the next meeting. Students' science process skills can be improved by repetition or practice so that students get used to doing the process (Putri et al., 2020; Rosanti & Sudibyo, 2022).

The low SPS indicator, when compared to other SPS indicators, is due to the learning that has been going on so far; generally, science lessons, and especially physics in schools, still lack training students in terms of designing experiments that include the ability to determine the variables to be measured, determine the tools and materials to be used in the experiment, and determine the experimental steps to be taken. This is one of the reasons why the M3 indicator is only obtained in the simple category. In general, teachers in the learning process, when related to practicum, only provide practicum LW that is ready to use without the need for students to think about the design of the experiment (Idrus et al., 2021; Sihaloho et al., 2018).

The fourth SPS indicator is conducting an experiment (M4) where learners determine the tools and materials used and design these tools and materials to collect experimental data used to test the hypothesis. Furthermore, the fifth SPS indicator is analyzing data (M5), where students collected data from observations during the experiment and described the data obtained in accordance with the directions given by the teacher. In indicators M4 and M5, the value obtained significantly increased, with an average of very good categories. Learning involving skill-related exercises can familiarize students with science process skills and help them understand concepts through experiments (Mutlu, 2020; Tanjung & Rahmatilla, 2020).

The last indicator is drawing conclusions (M6). Namely, students can decide on the data from the observations by answering the experimental objectives in the LW and determining whether the hypothesis that has been made is in accordance with the results of the experiments that have been carried out. In the indicator of drawing conclusions, there are 2 LWs with good categories and 1 LW with very good categories. This happens because, in LW 1 and 2, some groups are still confused in drawing a conclusion by answering the formulation of the problem and determining whether the hypothesis is correct. Therefore, further explanation is needed so that students can conclude the experimental data. This is in line with the research of Nosela et al. (2021), which states that students have not been able to explain and process data, which is not good. However, after learning at the next meeting, students experience progress where students can explain and draw conclusions

based on the results of data processing that has been done, as well as research by Listiani & Kusuma (2024), which states that for students to draw valid and good conclusions from the experiments or experiments that have been carried out, students need help from the teacher in order to build conclusions from them.

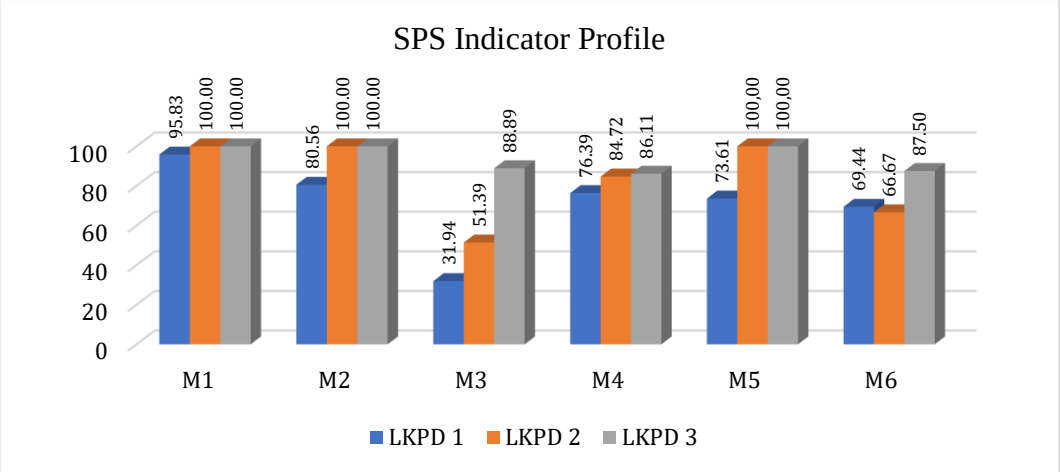

Figure 3 Achievement of SPS indicators

The achievement of SPS indicators on each LW can be seen in Figure 3 of the achievement of SPS indicators. Based on the results obtained, several indicators are categorized as good and not good, especially in LW 1. This happened because students were still confused at the time of the first experiment, did not focus on the experiment, and some members did not participate in group activities. Factors influencing the low SPS during the experiment are students who tend to be passive and do experiments according to the teacher's direction so that students do not feel something different (Irwanto et al., 2019; Jusman et al., 2022).

Various factors cause the low level of SPS among students; in addition to the factors previously mentioned, low SPS can be caused by internal and external factors. Internal factors include students' interest and motivation, concept understanding, and practical experience, while external factors include the role of the teacher, learning resources, and the learning environment. To improve SPS, educators need to create a supportive learning environment, implement more active learning strategies, and provide quality learning resources (Azizah et al., 2023; Megawati et al., 2020; Santiawati et al., 2022).

Overall, the average obtained on each indicator has reached the minimum SPS achievement, which is categorized as sufficient so that it can be concluded that the LW developed in the teaching module using the POGIL model can train students' science process skills. This is in line with research by Ghaida (2019), which states that there was an increase from the initial knowledge of students who were categorized as very lacking when before applying learning using the POGIL model to being skilled with the average score of students' SPS abilities that had increased at each meeting. This is in line with the learning theory underlying the POGIL model, namely constructivism learning theory, where students play an active role in the learning process, allowing students to learn new things beyond the information obtained.

CONCLUSION

This study only involves experimental classes due to the limited sample that can be observed, namely 1 class, so there is no control class. Based on the results of the research that has been done, it can be concluded that the profile on each SPS indicator is formulating a problem of 98.61 with a very good category, formulating a hypothesis of 93.52 with a very good category, identifying variables of 57.41 with a sufficient category, conducting

experiments of 82.41 with a very good category, analyzing data of 91.20 with a very good category, and drawing conclusions of 74.54 with a good category. Thus, implementing the POGIL model has positive potential in implementing students' science process skills. Therefore, further research is expected to re-emphasize SPS indicators, especially identifying variables, drawing conclusions, and organizing students to play a more active role in learning activities. Overall, the research shows that the approach improves learners' science process skills and facilitates active and collaborative learning. This is very relevant for educators and curriculum developers in designing more effective learning experiences in each subject area, such as physics, biology, chemistry, and science.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

IA conceptualized, background, and wrote the paper; AS and SH carried out data analysis and validation.

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