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Students' Science Literacy Exploration in Process Oriented Inquiry Learning (POGIL) Based Learning

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A R T I C L E I N F O

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A B S T R A C T

Science literacy is important because it allows individuals to understand, analyze, and interpret scientific information that is relevant to everyday life. The POGIL learning model, which focuses on structured inquiry activities, is expected to improve students' science literacy by integrating process-based and collaborative approaches. The purpose of this study was to see the effect of Process Oriented Guided Inquiry Learning (POGIL) on science literacy. This study used a quasi-experimental method, with a research design using one group pretest-posttest design. The sample was drawn by total sampling so that it used 30 students. The application of POGIL activated discussion and collaboration in the learning process. The results of the Wilcoxon test obtained a sig of 0.000 and it was concluded that there was an effect of POGIL on science literacy. The highest science literacy indicator was the Identifying Valid Scientific Opinions indicator with a percentage value of 98.33%. researchers had difficulty in directing students to collaborate, but this could be overcome by creating heterogeneous groups.

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INTRODUCTION

PISA states that scientific literacy is the ability to connect issues related to science and scientific ideas, as a reflective citizen. The results of the PISA assessment show that the scientific literacy of Indonesian students is low and has never reached the standard score set by PISA (Fuadi et al., 2020). The results of the PISA assessment are an important evaluation to improve the quality of education (Tohir, 2019). Indonesia's scientific literacy ability is in the low category (Firda, 2022). The factors causing low scientific literacy of Indonesian students are science misconceptions by students, teachers not mastering scientific literacy, and inadequate (Yusmar & Fadilah, 2023). So, something special needs to be done in developing scientific literacy (Muliaman et al., 2023).

The indicators of scientific literacy observed (Sutrisna, 2021), are: 1) identifying valid scientific opinions, 2) conducting effective literature searches, 3) understanding elements of research design and how they impact findings/conclusions, 4) creating graphs appropriately from data, 5) solving problems using quantitative skills, including basic statistics, 6) understanding and interpreting basic statistics, 7) making inferences, predictions, and drawing conclusions based on quantitative data (Muhammad & Fachrul, 2020). The low scientific literacy aspect indicates low mastery of scientific thinking and action. (Diana et al., 2015). Factors that influence scientific literacy include psychological factors (interest and motivation to learn), family factors, school factors (teacher teaching methods, facilities and infrastructure, and science teaching materials/media), and learning activities outside of school (Jufrida et al., 2019).

Learning strategies that can be used to improve scientific literacy are to implement Process Oriented Guided Inquiry Learning (POGIL). This learning model is the result of development by Moog and his colleagues based on constructivist learning theory (Pinasthi et al., 2024). POGIL is a student-centered teaching philosophy based on these concepts in which students work in teams on specially prepared activities that follow the learning cycle paradigm (Idul & Caro, 2022). There are many things that can be done to improve scientific literacy, including providing innovation in learning stages and teaching media (Sakdiah, 2022), (Safrijal et al., 2023).

LITERATURE REVIEW

POGIL learning is a learning model that focuses on the core understanding of concepts and digging deep understanding of a material and critical thinking skills. This learning model is useful in honing critical thinking skills, cooperative skills (in groups), providing ideas in group discussions and being able to defend arguments in group discussions and can provide opportunities to contribute ideas so that problems in the group are resolved. POGIL learning model has activities that focus on core concepts and science processes that can encourage and develop students' deep under.

There are five stages of the POGIL model, namely 1) orientation, which is the stage of conditioning students and providing motivation or stimulation for students to focus their attention, 2) exploration, which is the stage where the teacher guides students to form groups and discuss, 3) concept discovery, which is the stage of guiding students in observing and identifying problems faced, 4) application, which is the stage of applying concepts found in a new context, and 5) Closing, which is the stage of presenting what students have obtained during learning. (Putri & Gazali, 2021) (Hainun et al., 2022). POGIL has a positive impact in the form of improved learning outcomes and critical thinking skills. (Yani Widyaningsih & Saputro, 2012). Qualitative research results state that students prefer POGIL learning. (Richard Moog et al., n.d.).

Stages of pogil learning carried out in this study area (Yoki Handayani et al., 2015), (Zamista, 2016), (Yadav et al., 2021):

a) Orientation, preparing students to learn physically and psychologically. In this step, the activities carried out by the teacher are to motivate students to participate in learning activities, determine learning objectives, determine the criteria for student learning outcomes, which indicate whether a student has achieved learning objectives or not, create student interest (student interest in science), arouse students' curiosity and make connections with the knowledge that students have previously had either through experience or observations that they have made, present narratives, illustrations, demonstrations or videos that can be observed by students to start learning new things, which must then be analyzed by students.

b) Exploration, at this stage, after conducting observations, students are expected to be able to communicate the results of observations, classify, make inferences (deductions or conclusions based on observation results) or take measurements. What is done at this stage is determining the variables needed and will be analyzed based on the results of observations in the previous stage, proposing hypotheses (stating the relationship between variables), designing experiments to test hypotheses, collecting data based on the experimental design that has been made, checking/analyzing data or information, describing the relationship between variables based on data that has been collected through experiments.

c) Concept formation, this stage is carried out by the teacher giving questions that can guide students to think critically and analytically related to what students have done in the exploration section. These questions function to help students define exercises, guide students to information, guide students to open the right relationships and conclusions, and help students to construct cognitive abilities through learning.

d) Application, at this stage, students use new concepts in exercises, problems and even research situations. At this stage, students use new concepts in exercises, problems and even research situations. What is done at this stage is Exercises provide students with opportunities to build self-confidence by providing simple problems or familiar contexts, problems in the form of transferring new knowledge to unfamiliar contexts, synthesizing with other knowledge and using that knowledge in different ways to solve problems related to real-world contexts, research questions in the form of developing learning by raising new issues, questions or hypotheses.

e) Closing, learning activities end with students validating the results they have achieved, reflecting on what has been learned and assessing their performance in learning. Validation is done by reporting the results they get with classmates and teachers, to find out their perspectives on the content and quality of the content. In this section, students are also asked to do a self-assessment, by filling out a self-assessment sheet. Self-assessment is the key to improving student performance. When they know what they are doing well, they will maintain and even develop those positive things.

METHODOLOGY

This research applies a quantitative approach with a quasi-experimental method, with a research design using a one group pretest-posttest design.

Table 1. One Group Pretest-Posttest Design

Pretest	Treatment	Postest
O_1	X_1	O_2

Hypothesis proposed:
Ho: POGIL is unable to influence scientific literacy
Ha: POGIL is able to influence scientific literacy

This study used students of the 5th semester Physics Education study program as the population and used them as samples with the total sample sampling technique, so that 30 people were obtained as samples. This research instrument used 10 literacy test questions. Data analysis began with the hypothesis prerequisite test, namely the normality test and continued with the hypothesis test, namely the Wilcoxon test. In addition, it also uses percentage analysis for each indicator of scientific literacy.

RESEARCH RESULT

This research was conducted by implementing POGIL learning and measuring students' scientific literacy. Before the hypothesis test, a prerequisite test was carried out, namely the normality test. The normality test of the pretest-posttest data used the Shapiro-Wilk test and was tested using the SPSS application. The results of the data normality test can be seen in the following table.

Table 2. Normality Test

	Shapiro-Wilk		
	Statistic	*Df*	*Sig.*
Posttest	.832	30	.001
Pretest	.856	30	.000

The significance level for the posttest data is 0.01, this value is less than 0.05, meaning that the posttest data is not normally distributed Hypothesis testing uses non-parametric tests, namely the Wilcoxon test.

Tabel 3. Wilcoxon test

Test Statistics[a]

	Postest-Pretest
Z	-4.849[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

The Wilcoxon test yielded a significance of 0.000 or less than 0.005, this shows that there is an influence of POGIL learning using science literacy.

The results of statistical tests show that POGIL learning has an effect on students' scientific literacy. This is because POGIL learning directs students to actively discuss, develop critical and analytical thinking skills. POGIL learning can improve learning outcomes (Agung et al., 2022), as well as generic science skills (Arsy & Octarya, 2022).

Science literacy for students according to the indicators can be seen in the following image.

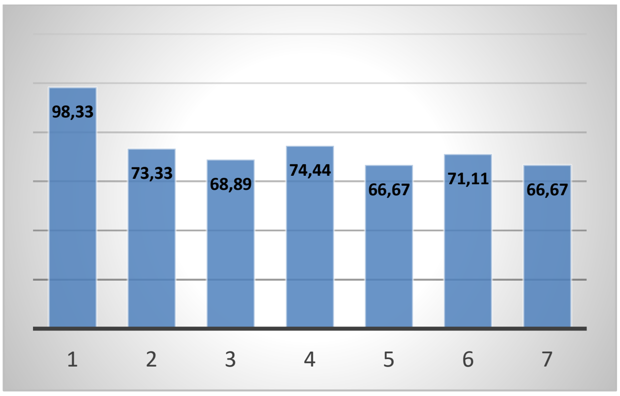

Figure 1. Percentage of scientific literacy for each indicator.

Based on the image above, it is known that:

1) Indicator of Identifying Valid Scientific Opinions (98.33%), this highest percentage indicates that participants or respondents have very good abilities in identifying valid scientific opinions. This ability is an important foundation in scientific literacy because it involves critical thinking skills to distinguish reliable information from unreliable information.
2) Indicator of Conducting Effective Literature Search (73.33%), This percentage shows a good level of ability, but there is still room for improvement. This ability is important in the context of scientific literacy to find relevant and quality sources in research.
3) Indicator of Understanding the Elements of Research Design and Its Impact on Findings/Conclusions (68.89%), understanding of research design shows a fairly good level of ability. This understanding is important to understand how research is designed and how research results should be interpreted.
4) Indicator of Making Graphs Appropriately from Data (74.44%), this shows that participants are generally quite good at presenting data visually, which is an important skill for simplifying quantitative information.

5) Indicator of Solving Problems Using Quantitative Skills, Including Basic Statistics (66.67%), indicating that the ability to solve quantitative problems and use basic statistics still needs to be improved. These skills are important in scientific data analysis and in data-based decision making.
6) Indicator of Understanding and Interpreting Basic Statistics (71.11%), shows good understanding, although there is still room for improvement in the interpretation of statistical results.
7) Indicator of Making Inferences, Predictions, and Drawing Conclusions Based on Quantitative Data (66.67%), indicating that participants still need to develop skills in drawing conclusions and making predictions based on quantitative data. This ability is important in applying research results to solve problems or make decisions.

Overall, the results show that the highest scientific literacy ability is in identifying valid scientific opinions (98.33%), while the lowest ability is in solving problems using quantitative skills and making inferences based on quantitative data (66.67%). This indicates the need for training or strengthening skills in quantitative aspects and statistical abilities in scientific literacy to strengthen data analysis and drawing conclusions. Efforts to improve scientific literacy skills can be focused on aspects of basic statistics, quantitative analysis, and data interpretation, considering that these three aspects show lower scores compared to other skills related to scientific literacy.

DISCUSSION

This study shows that the Process-Oriented Guided Inquiry Learning (POGIL)-based learning model has a positive impact on students' scientific literacy. Through the implementation of POGIL, students experienced a significant increase in their ability to understand scientific concepts, think critically, and solve problems quantitatively. The POGIL model, which emphasizes a structured and collaborative inquiry process, helps students not only master science material, but also develop analytical thinking skills and the ability to work in groups.

The results of this study show that POGIL is able to create a more active learning environment, where students participate directly in the learning process and have the opportunity to develop a deep understanding of science. Students also showed a positive response to this learning model, which made them more motivated to learn and better able to relate science concepts to real-life contexts.

Thus, POGIL can be used as an effective alternative learning model in improving scientific literacy. This model supports the development of scientific literacy as one of the main competencies needed by students in facing the challenges of an ever-evolving world. The results of this study also suggest that POGIL be considered for wider application in the science curriculum, as well as adapted at various levels of education to maximize the development of students' scientific literacy skills.

The limitations of this study are: 1) The relatively short duration of POGIL implementation in this study may not be enough to provide maximum impact on students' scientific literacy. Research conducted over a longer period of time may provide different results regarding the understanding and mastery of scientific literacy. 2) Not all students have the same understanding of the POGIL approach. Some students may need more guidance and time to adjust to this method, which may affect the results of their scientific literacy exploration process. and 3) Several external factors that may affect the results of the study, such as the learning environment, the availability of learning resources outside the classroom, and support from the family, cannot be fully controlled. This can affect student motivation and participation during the POGIL-based learning process.

CONCLUSION AND RECOMMENDATION

The implementation of POGIL learning has an impact on scientific literacy. The highest scientific literacy indicator is identifying valid scientific opinions and the lowest is making inferences based on quantitative data. In conclusion, this study demonstrates that the Process-Oriented Guided Inquiry Learning (POGIL) model significantly enhances students' scientific literacy by fostering critical thinking, problem-solving, and collaborative learning. The active and structured inquiry-based approach encourages students to engage deeply with scientific concepts and apply them in real-world contexts, thus improving their motivation and understanding. While the results are promising, the study acknowledges some limitations, including the short duration of POGIL implementation, variations in students' adaptation to the method, and external factors such as the learning environment and family support, which may influence the outcomes. Despite these challenges, the findings suggest that POGIL is a valuable pedagogical tool that can be further explored and integrated into science curricula at various educational levels to promote the development of scientific literacy, a critical competence for students in navigating an increasingly complex and dynamic world.

ADVANCED RESEARCH

For further researchers, POGIL should be implemented gradually to introduce students to the inquiry-based approach, especially for those who are not yet familiar with this method. Gradual steps will help students adjust and understand the concept of inquiry better. And in implementing POGIL, it is important to form heterogeneous learning groups, taking into account students' abilities and characteristics. This will ensure that students support each other and contribute effectively in the group.

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