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The Effect of Static Fluid Pressure Learning with Predict-Observe-Explain (POE)-Oriented Student Worksheets on Science Process Skills

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Abstract – *The purpose of this study was to investigate the effect of static fluid pressure learning with Predict, Observe, Explain (POE)-oriented student worksheets on the eighth-grade students' science process skills. This research employed a non-equivalent control group design. A total of 166 students from five classes in class VIII at State Junior High School 03 in Bengkulu City represented the research population. Students in class VIII-1 (control group) and class VIII-2 (experimental group), for a total of 58 students, were selected as subjects using non-probability sampling and the convenience sampling method. By applying non-parametric inferential statistics, particularly the Mann-Whitney U test, the hypothesis was examined. The results confirm that the use of POE-oriented worksheets in learning the concept of pressure in static fluids has a statistically positive effect at the significance level (0.05) with a p-value (0.003) on science process skills, and the effect size (r=0.39) is in the medium category. The availability of worksheets that rely on scaffolding strategies such as POE may enable students in secondary schools to construct their own knowledge during the learning process.The provision of worksheets that employ scaffolding techniques, such as the Predict-Observe-Explain (POE) approach, has the potential to facilitate the development of students' knowledge construction and science process abilities in secondary school settings.*

Keywords: *predict-observe-explain; science process skills; static fluid; student worksheets*

I. INTRODUCTION

Teachers frequently view science as a product rather than a process. Accordingly, teachers perceive science as a compilation of factual knowledge, concepts, principles, and laws, they often choose a pedagogical approach centered on elucidating the concepts, principles, and laws (Lederman et al., 2013; Cofré et al., 2019). However, teachers who possess a comprehensive comprehension of science, perceiving it not solely as a product but as a process, are more inclined to create and execute science curricula that cultivate students' ability to engage actively in scientific inquiry.

Gunawan et al. (2019) stated that science encompasses not only its content but also its process, representing its essence. Hence, the intention of this study is to introduce science instruction from the viewpoint of science as a product and process in public middle schools.

Ideally, the primary objective of science education should be the acquisition of fundamental competencies, such as attitudes, knowledge, and skills. The strategy for teaching science at the elementary and secondary levels is therefore based on scientific inquiry. Students can acquire and exercise reasoning, higher-order thinking skills, and science process skills through a focus on scientific inquiry (Tilakaratne & Ekanayake, 2017; Tawil et al., 2023).

The preliminary study focused on examining the scientific learning process in public middle schools, namely SMPN 3 Bengkulu. This was accomplished by classroom observation and conducting semi-structured interviews with science teachers. The data presented indicates a higher propensity among teachers to employ didactic methods, wherein they elucidate concepts and assign science textbook tasks for learners to answer. The pedagogical methods employed by teachers have a significant impact on students' inclination towards memorizing formulas and their approach to problem-solving. Moreover, the primacy of the teacher's perspective on science as an outcome outweighs the significance of the students' perception of science as a process.

Various research findings have been published about researchers' efforts to introduce learning resources and learning models that can help teachers plan and carry out science learning at various levels of education, focusing not only on science as a product but also on science as a process. For example, Mamun et al. (2020) produced an electronic module that adopted POE (Predict, Observe, Explain) as the basis of a revised pedagogical strategy to create online learning by incorporating an innovative element of the evaluate (E) phase into the POE strategy. Furthermore, the study conducted by Nurlina, (2020) yielded the finding that the implementation of the guided inquiry learning model had a more significant impact on enhancing students' science process skills.

In a recent study by Putri (2016), a static fluid pressure worksheet was developed using the POE strategy to improve science process skills (SPS). The present worksheet was specifically designed for students in middle school and underwent a thorough review process with six experts. This rigorous evaluation aimed to ensure the accuracy and readability of the content, aligning it with the cognitive abilities and educational needs of middle school students.

Also, the worksheet's readability was judged by how well the students understood it. In this study, however, the worksheet made by Putri (2016). Was used to examine the effects of worksheets on SPS such as observing, labeling, and measuring as basic

SPS (Derilo, 2019; Ramdayani et al., 2023) constructing operational definition; identifying and controlling variables; formulating hypotheses; experimenting; and interpreting data as integrated SPS (Elfeky et al., 2020).

With regards to the focus of this study, the research question is whether the use of POE-oriented student worksheets has an effect on science process skills and, if so, how much of an effect it has on enhancing the process skills of eighth-grade students. As a result, the intent of this study is to examine the effect of the use of POE-oriented student worksheets on the science process skills of eighth-graders to learn static fluid concepts.

II. METHODS

The design of this study is quasi-experimental because the researchers cannot control all external variables that influence the implementation of the treatment. The independent variable (treatment variable) is the use of POE worksheets, and the dependent variable is the mastery of science process skill.

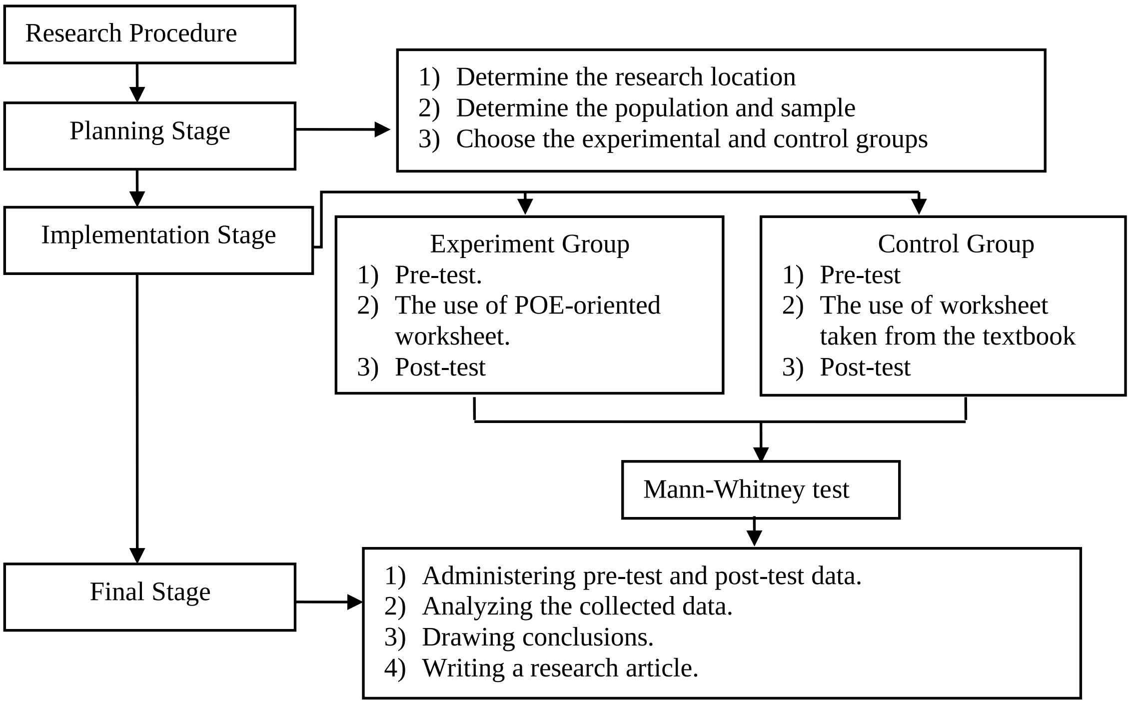


Figure 1. Flow chart research process

The process of research employed in this study is illustrated in Figure 1. The study begins by determining the educational institutions that will be the focus of investigation. The research site, State Middle School 03 (SMP Negeri 03) in Bengkulu City, was selected for the study during the second semester of the 2022/2023 academic year.

The targeted school is located in the center of the city and on the seashore. The students come from coastal and urban communities with a variety of occupations, including fishermen, traders, civil servants, and laborers.

There were 166 students in class VIII at SMPN 03. This included 32 students in class VIII-1, 26 students in class VIII-2, 36 students in class VIII-3, 36 students in class VIII-4, and 36 students in class VIII-5. Non-probability sampling and convenience sampling were employed for sample purposes.

Convenience sampling is used when other types of sampling methods are impossible to use since researchers have no access to the full target population for a representative sample excluding to Class VIII-1 dan Class VIII-2 (Taherdoost, 2016; Winton & Sabol, 2022). Consequently, the research samples consisted of 58 students from classes VIII-1 and VIII-2.

Prior to treatment, the experimental group (O_E) and control group (O_C) were administered a pretest to assess students' SPS (see. Figure 2). The learning process for the two groups studying static fluid pressure occurred over the course of five meetings.

Students in the experiment group, on the other hand, used the POE-oriented worksheets, while those in the control group used the standard student worksheets. At the end of the course, each group was administered a post-test to determine how well they had learned the SPS. The implementation of the POE-oriented worksheet affects class VIII students' SPS when there is a statistically significant difference in the average SPS score between the two groups.

Experimental Group (O_E)	Pre-test	Treatment	Post-test
	O_{E1}	X	O_{E2}
Control Group (O_C)	O_{C1}	~	O_{C2}

Figure 2. Non-equivalent control group design research design

The experimental and control groups are determined by the simplicity with which permission can be obtained and the similarity of the learning environment in both classes (Miller et al., 2020). Class VIII-1 and Class VIII-2 were taught by the same science teacher, who was also willing to participate in the research process. The learning outcomes for students in the two classes were comparable, and the researchers knew the students through an internship program. Class VIII-1 served as the control group, while class VIII-2 served as the experimental group.

Techniques for gathering data are (a). observation to determine how the learning process is being put into practice in both classes The experimental group received instruction from researchers, while science teachers conducted the observations. In contrast, the science instructor taught the control group of students while the researcher made observations. The observation sheet is the tool that the two observers in each class used to collect data. (b). Pre-test and post-test tests using paper and pencil to gauge pupils' proficiency with SPS (Gultepe & Kilic, 2015). To gather mastery information on SPS, a total of ten essay questions were used. To help the researcher grade each item, a scoring rubric was created.

Class IX students who had studied the concept of static fluid pressure participated in empirical tests before the questions for the pre- and post-tests were developed. Analyzing experimental data determined the validity of the items, the reliability of the SPS test, the level of difficulty and the discriminatory power of the SPS items.

Test items development employed the test-specification table that had three major columns, namely indicator of competences, science process skills, and number of items (see Table 1). The 12 items were based on signs of competence attained and indicators of science process skills, including interpreting, asking questions, designing an experiment, applying concepts, observing, and communicating.

Table 1. Test specification table for science process skill (SPS)

Indicators of Competence	Science Process Skills	No. items
A. Solid pressure		
Explain the relationship between force and surface area to pressure	Interpret	8
B. Liquid pressure		
Explain Archimedes' Law	Ask questions	1, 2
Explain Pascal's law on objects in everyday life	Designing an experiments	4, 11
	Implement the concept	7, 12
Explain the pressure of a liquid at a certain depth	Designing an experiment	3
	Observe	5
	Implement the concept	6
	Communicate	9, 10

Figure 3. depicts one of the scientific process skill questions developed using the test specification table science process skills (see Table 1).

Question no.6.
The picture shows a diver enjoying the beauty of the waters around Indonesia.

Source: Widyawati (2020)

If density is 1 kg/m3 and g is 10 m/s2, what is the static pressure that a diver will experience at a depth of 15 m below sea level?

Figure 3. An example of the science process skill test

As a prerequisite for the parametric test, it is necessary to know the data distribution pattern of the dependent variable (science-process skills) before testing the hypothesis. So that the normality test could be conducted on both groups' pre- and post-test data. Determine if the pre- and post-test data are normally distributed according to the shape of the normal curve, with data centered around the mean and median.

The Kolmogorov-Smirnov method is utilized for the normality test because the number of data points exceeds 50 (Demir, 2022; Orcan, 2020). Additionally, a homogeneity test is conducted to determine whether or not the population variances of the two samples are identical. If the data categories are normally distributed, the F test (Levenee) is used to examine the homogeneity of variance (Kim, 2015). The null hypothesis tested is as follows.

H_o: The use of POE-oriented worksheets in science instruction had no effects on the students' understanding of science process skills.

III. RESULTS AND DISCUSSION

There were 21 students of the ninth-grade at a state middle school in the city of Bengkulu participated in pilot testing of scientific process skill assessments. The pilot test administration was made possible with the assistance of the ninth-grade science teacher. Table 2 shows the results of the study of the empirical test data.

Table 2. Findings for the empirical test data of science process skills

No. item	r_{cal}	Sig. (2-tailed)	Difficulty Index	Criteria	Discrimina-tion Index	Criteria	Decision
1	0.65	0.001	0.56	Good	0.78	Easy	Modify
2	0.578	0.006	0.61	Good	0.68	Moderate	Retain
3	0.494	0.023	0.25	Enough	0.23	Difficult	Modify
4	0.667	0.001	0.32	Enough	0.21	Difficult	Modify
6	0.639	0.002	0.48	Good	0.60	Moderate	Retain
7	0.681	0.001	0.44	Good	0.44	Moderate	Retain
8	0.673	0.001	0.41	Good	0.40	Moderate	Retain
10	0.501	0.021	0.33	Enough	0.59	Moderate	Retain
11	0.643	0.002	0.58	Good	0.62	Moderate	Retain
12	0.501	0.021	0.50	Good	0.52	Moderate	Retain

Note : 0.433 (N = 21);
**: Correlation is significant at the 0.01 leve (2-tailed)
*: Correlation is significant at the 0.05 level (2-tailed)

Based on the trial data analysis of the SPS items (shown in Table 2), the product-moment correlation (KR-20) was used to figure out the test items' internal consistency.

It was found that 10 items were declared valid, but items 5 and 9 had questions that were invalid (not appearing in Table 2). The reliability test of the SPS test instrument is calculated using Cronbach's Alpha formula as a measure of internal reliability obtained at 0.75. These results indicate that the reliability coefficient is included in the moderate category, so 10 questions are reliable for measuring SPS.

Test items with an index of difficulty in the interval of 0.25–0.75 and the smallest discrimination index of 0.40 can be used for the SPS test. So that the items that do not meet the requirements, such as questions no. 1, 3, and 4, are revised in the stimulus section, and questions and answer options are available. The item for easy criteria has been revised in the stimulus of the question (Figure 4b).

One morning, Zara was sitting by the pool at her house. One mosquito was sitting on top of the water, as shown in the picture. Write two questions based on the picture and the previously mentioned list of events.

Figure 4a. Item #1 (Prior to revision)

One morning, Zara was sitting by the pool around her house. He noticed a mosquito perched on the surface of the water (see picture). Based on the picture above, write down two questions: Why do mosquitoes not drown?

Figure 4b. Item #1 (After revision)

Content delivery

Following are excerpts from the implementation of the learning process in the experimental group (Class VIII-2), which utilized POE-oriented student worksheets with material on hydro-static pressure. A lecture plan guided the learning process, which could be observed by two observers in Class VIII–2.

In the initial tasks, the teacher asked a question (a stimulus) to find out what the students already know about hydrostatic pressure in liquid. For example, "What would you feel if you dove to the bottom of the pool?" The students' answers were different, such as "My ear hurts" and "My chest feels tight and it's hard to breathe." The teacher responded to student answers by asking and answering questions to get students to think, "What does the human ear or respiratory organ feel like when it is at a certain depth below the surface of the water?"

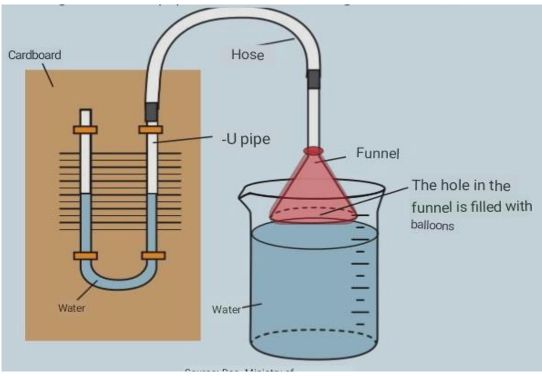
In the core tasks, the instructor (researcher) informed the learning objectives and explained the concept of hydro-static pressure and its applications in ordinary life via explanation and discussion techniques. The instructor asked students to settle into their respective groups and distributes a POE-oriented worksheet to each group.

Figure 5. Learning activities in experimental group

After ensuring that every student was in a group, the teacher stated that the task at hand was to conduct an experiment utilizing the equipment and supplies on the table. They were instructed to make predictions and then listed the justifications for it. Each group carried out an experiment and recorded the findings of their observations and hypotheses on the worksheet that the teacher had provided. Each group was asked to explain any discrepancies between predictions and observations.

Prediction Phase

In this phase, the teacher displayed a U-pipe filled with liquid and a funnel connected by a plastic hose. A beaker filled with water (Figure 6).



Source: Kemendikbud

Figure 6. Liquid pressure experiment

Students were reticent to voice their opinions because a similar learning process had never been implemented before (teacher's admission). Students were therefore instructed to freely record their responses to the following queries.

"Predict what will happen to the water surface in the U-pipe when the funnel is immersed in water in the beaker. Write down and explain the reasons in the student worksheet!"

Observation and Explanation Phase

In this phase, the instructor assigned groups of students an experiment involving hydro-static pressure (Figure 6). All students were required to read and adhere to the instructions for the experimental activities outlined in the worksheet. Students were required to record their observations by responding to the questions below.

"What happens to the top of the water in the U-tube when the funnel is put in a beaker filled with water? Look at how the height of the liquid inside the *U*-shaped pipe and the depth of the funnel in the beaker glass change over time. Write down your findings and why you think the results are reliable on the worksheet!"

Discussions between groups were prohibited because the investigation was conducted in groups. In the next phase of the activity, students were required to compare their previous predictions with the results of their observations by answering the following questions:

"Compare your observations with your earlier predictions. Is a complement present or not? Justify your reasoning."

One representative from each group was given the opportunity to report the accord between predictions and observations and provided an explanation as to why it is or is not appropriate. The teacher facilitated group discussions and provided support for each explanation offered by group members.

Teachers and students reflected on the learning process that is taking place during closing learning tasks.

On May 12, 2023, a description of the execution of the learning process in class VIII-1 (control class) using hydro-static pressure material was presented. Lesson plans and student books were used in the classroom. Initial, core, and closing activities constitute learning activities.

In the initial task, the teacher asked students to organize their stationery and textbooks. The teacher inquired, "Who among you enjoys swimming?" The plurality of students responded, "Yes, ma'am, I love swimming." The teacher asked once again, "What do you experience when you dive to the bottom of the pool?" The majority of students responded that it is difficult to breathe and that their ears hurt. "The experiences you have had are closely related to the topic we will be studying today."

In this task, the teacher explained the topic through Power Point. Each slide shown on the projector was accompanied by an explanation. After elaborating on the concept of hydro-static pressure and its application in everyday life, the instructor invited students to pose questions about what they did not comprehend about the topic.Yet, students did not take advantage of the opportunity.

Figure 7. Learning activities in the control group.

Teachers and students discussed the lessons they have learned during closing learning tasks

Students in classes VIII-1 and VIII-2 took the pre-test before the learning process began in both groups. Also, the post-test was given in both groups with the same questions as the pre-test after the learning had taken place. Data from student responses in both groups were recorded and analyzed with SPSS package program version 25 to derive descriptive pre-and post-test data. With regard to the data shown in Table 3, the mean test score for science process skills in the experimental group (20.65 ±10.53) is similar to the mean score of the control group (17.69 ±9.00).

Table 3. Descriptive data of science process skills of experimental and control groups

Data	Experimental Group (N=26)		Control Group (N=32)	
	Pre-test Data	Post-test Data	Pre-test Data	Post-test Data
Mean	20.65	65.04	17.69	47.38
Std Deviation	10.53	21.46	9.00	19.28
Maximum	46.00	94.00	43.00	84.00
Minimum	4.00	16.00	3.00	14.00

The highest and lowest scores of the two groups are nearly identical since the experimental group has the highest score (46.00) and lowest score (4.00), but the control group has the highest score (43.00) and the lowest score (3.00). In other words, students in class VIII-1 (control group) possessed comparable prior knowledge of science process skills (SPS) as students in class VIII-2 (experimental group)

The mean score on the post-test for science process skills is different for the experimental group and the control group (17.66). However the difference between the mean scores of the two groups needs to be checked using hypothesis testing to see if the difference between the average scores of students in the control and experimental groups on SPS is considered statistically significant. The difference is likely due to how the POE-based worksheets affected the learning process in the experimental class and the control class, which used the worksheets along with the textbook.

Prior to conducting a hypothesis test, it is necessary to perform the prerequisite tests, namely the normality test and homogeneity test, in order to determine the hypothesis test to be employed. The prerequisite test was administered using the SPSS 25 version, and the results of the statistical analysis of the test for normality are summarized in Table 4.

Table 4. Preand post process science skills normality test results

Tes	Group	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pre	Experiment	0.208	26	0.005	0.926	26	0.062
	Control	0.149	32	0.070	0.942	32	0.085
Post	Experiment	0.195	26	0.012	0.932	26	0.086
	Control	0.125	32	0.200	0.948	32	0.126

The normality test determines whether the pre-and post-test data are normally distributed or not. Based on Table 5, the p-values obtained from the Kolmogorov-Smirnov (Mishra et al., 2019) test indicate that the pre-and post-test p-values for the experimental group were below the significance level of 0.05. In contrast, the pre-and post-test p-values for the control group were more than 0.05, suggesting that the data did not follow a normal distribution. The result of Kolmogorov-Smirnov (K-S) test is supported by the Shapiro-Wilk test. Since a parametric test was not met, the Mann-Whitney U test was employed instead of the independent t-test, namely, two groups: independent sampel (Sanders et al., 2019). The results of the Mann-Whitney U test are presented in Table 5.

Table 5. The results ofthe Mann-Whitney U test

Test	**Group**	**Mean Rank**	**Z score**	**Asymp. Sig. (2-tailed)***
Pre	Experimental Control	31.83 27.61	-0.950	0.342
Post	Experimental Control	36.85 23.53	-2.990	0.003

Note: Significance level: 0,05.

The intention of the POE-oriented worksheet was to provide scaffolding as learning support to complete tasks. The purpose of this study was to examine the impact of incorporating POE-oriented worksheets into a hands-on activity on the development of process skills. The increase in science process skills was assessed by a written test administered to eighth-grade students who had completed worksheets. Using the Mann-Whitney test, it was determined whether the increase in science process skills was statistically significant.

Table 5 shows that the experimental group's pre-test score for science process skills (mean rank: 31.83) was higher than the control group's (mean rank: 27.61). The data showed that there was no statistically significant difference between the experimental group and the control group in terms of their scores on the pretest science process skills test (z = [-0.95], p = [0.342]). This shows that the science process skills of the students in classes VIII-1 and VIII-2 were nearly equal prior to studying.

In addition, a Mann-Whitney U test was conducted to compare the post-test scores for science process skills between the experimental and control groups. Using the data in Table 6, the experimental group's science process skills pretest score was significantly higher than the control groups, z = [-2.99], p = [0.001]. This indicates that the science process skills of eighth-grade students in classes VIII-1 and VIII-2 differ considerably after learning.

Effect size estimation can be used to determine the impact of incorporating POE-oriented worksheets into eighth-grade science instruction on the improvement of science process skills. According to Läkens, (2022), the advantage of effect size estimation is that it enables researchers to ascertain the practical or theoretical treatment effect.

The dependent variable in this study is the SPS, while the independent variable is the utilization of POE-oriented worksheets during the educational process. The calculation of the estimated effect size is indicated by the correlation coefficient between the variables, as shown in Table 6. As elucidated by Läkens, (2022), the estimated effect size serves as a metric for quantifying the strength of the association between variables under investigation.

Table 6. Effect size and interpretation cohen

Data (N = 58)	**Z score**	***r*-coef****	**Interpre-tation**
Science Process Skill	-2.99	0.39	medium

Note: *r = 0,01 (low); 0,30 (medium); 0,50 (high)
** calculated by the formula: $r = \frac{|Z|}{\sqrt{N}}$

According to the data presented in Table 6, the average rank score prior to the intervention did not exhibit a statistically significant difference between the experimental group and the control group, as evidenced by the p-value (0.342 > 0.05). This implies that there is a notable similarity in the science process skills of students in both groups.

Following the implementation of the POE-based worksheet in the experimental group, statistical analysis using the Mann-Whitney U test revealed noteworthy disparities in the mean rank across the groups, as evidenced by the p-value (0.003<0.05). The findings of this study suggest that the implementation of POE-oriented worksheets had a significant impact on student's performance in the SPS, as opposed to the performance of students who used worksheets derived from their textbooks.

This finding is supported by previous researchers stating that the application of the POE learning strategy improves science process skills in the learning of the concept of the human digestive system (Kurniawan et al., 2022) and the concept of the coordination system (Yulianti et al., 2018). Algiranto et al. (2019) discovered that the use of POE-based student worksheets enhances students' science process skills in laboratory settings during physics experimentation. Moreover, the implementation of student workbooks integrated into the POE strategy can significantly enhance students' comprehension of the concept of reaction rates (Sari et al., 2020).

Explaining any discrepancies between students' predictions and observations is the most crucial aspect of the POE strategy, and how students can apply the learned concepts to ordinary life. The results suggest that teachers can use POE tasks to devise learning activities and strategies that begin with students' perspectives rather than their own. POE may appear to be a slow-paced method of instruction, but it can improve students' critical thinking skills.

The utilization of tailored worksheets that align with the individual learning needs of students can effectively enhance their comprehension of science concepts and process skills (Algiranto et al., 2019; Ika & Doa, 2021). Sudirman & Qaddafi (2023) conducted a study that demonstrated a significant improvement in eleventh-grade students' comprehension of Hooke's law following the implementation of student worksheets that incorporated PhET simulation.

However, in the current study, students employed a worksheet that coupled the Predict-Observe-Explain (POE) strategy to provide help and guidance throughout a practical learning experience focused on the topic of static fluid pressure. The worksheet functioned as a learning tool for the students. Mamun et al. (2020) claim that scaffolding functions as a type of educational assistance that provides learners with a contextual structure, facilitating their successful completion of activities that may initially exceed their existing skill level.

The results of this study verify that POE tasks could be incorporated into student worksheets to help them learn for hands-on classroom tasks. Since then, students have actively done scientific research and worked on their science process skills. For students to learn science process skills well, middle school science teachers have to provide scaffolding as learning support so that students can do tasks that are beyond their initial level of ability.

IV. CONCLUSION AND SUGGESTION

It may be deduced from the research and discussion's findings that two key points: (1) Using the POE-oriented worksheets to teach students about the concept of static fluid pressure has a statistically significant (0.05) effect (p-value = 0.003) on learners' science process skills. (2) The effect size (r = 0.39), which is in the medium category, illustrates how the POE-oriented worksheets have a positive effect on science process skills.

The availability of worksheets that rely on scaffolding strategies such as POE may enable students in middle schools to construct their own knowledge and science process skills during the learning process.

Concerning the study's limitations, the sample size and research area are a couple of restrictions. The investigation was conducted with the participation of 58 middle school students in a public school setting. In order to more broadly generalize the findings, it is recommended that future research be conducted with a larger sample size and in various types of public and private schools.

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