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The Effect of Scaffolding Prompting Questions on Scientific Writing Skills in the Inquiry Classroom

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ABSTRAK

Menulis ilmiah merupakan keterampilan penting sebagai indikator untuk menentukan kemampuan seseorang dalam menganalisis dan merefleksikan hasil berpikir. Namun demikian, siswa seringkali mengalami kesulitan dalam mengembangkan kemampuan menulis. Penelitian ini mencoba solusi dengan menerapkan pembelajaran inkuiri dengan memberikan bantuan berupa scaffolding prompting question. Tujuan penelitian ini adalah menganalisis pengaruh scaffolding prompting question dalam pembelajaran inkuiri terhadap keterampilan menulis ilmiah. Jenis dari penelitian adalah quasi eksperimen yang dilaksanakan di sekolah menengah atas. Selama pelaksanaan pembelajaran, kelas eksperimen diberi perlakuan berupa pembelajaran inkuiri berbantuan scaffolding prompting question, sedangkan kelas kontrol diajar dengan pembelajaran konvensional. Keterampilan menulis ilmiah siswa diperoleh berdasarkan hasil penilaian laporan praktikum yang telah diselesaikan siswa pada setiap akhir pembelajaran selama tiga kali pelajaran. Hasil uji statistik terhadap keterampilan menulis ilmiah menggunakan independent sample t-test menunjukkan bahwa keterampilan menulis ilmiah siswa kelas eksperimen berbeda dengan kelas kontrol. Berdasarkan hasil penelitian ini, dapat disimpulkan bahwa scaffolding prompting question dalam pembelajaran inkuiri berpengaruh secara signifikan terhadap keterampilan menulis ilmiah siswa.

ABSTRACT

Scientific writing is an essential skill as an indicator to determine the ability to analyze and reflect on the results of thinking. However, students often experience difficulties in developing writing skills. This study tried a solution by applying inquiry learning by assisting with scaffolding prompting questions. The aims of this study is to analyze the effect of the scaffolding prompting questions in guided inquiry learning on scientific writing skills. The type of this research is a quasi-experiment conducted in senior high school. Science learning is conducted in two classes; experiment and control class with different treatments. The experiment class implemented guided inquiry learning assisted by a scaffolding prompting question, while the control class was taught with guided inquiry learning without scaffolding. Scientific writing skills are obtained from the evaluation of practicum reports that students have done after being trained for three lessons. The results of statistical tests on scientific writing skills using the independent sample t-test showed that the scientific writing skills of the experimental class students differed from the control class. Then, it can be concluded that the scaffolding prompting question in guided inquiry learning significantly influences scientific writing skills.

1. INTRODUCTION

Writing skills are one form of communication skills that can facilitate students to express ideas and construct understanding as one of the goals in science teaching. Writing skills are an essential part of learning activities because these skills can be used as a way to express various ideas or writing-to-learn (Kieft et al., 2008; Newel, 2006; Wagner, 2010). Writing skills are an essential aspect in science learning and an indication of the success of education and useful for students when entering real life (Hasani, 2016; Supeno & Maryani, 2019). Writing skills are one of the higher-order thinking skills, and these skills can be used to determine the ability to analyze and reflect on the results of their thinking. Writing activities can

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be realized through practicum activities about science (Arifin & Retnawati, 2017; Chang et al., 2011). Writing reports on practical work on science, concisely and well organized, is a manifestation of the proper interpretation of all possible activities about science. Analysis and writing are high-level thinking processes that require cognitive skills and abilities, such as supporting and refuting a theory (Deiner et al., 2012; Moskovitz & Kellogg, 2011). With writing skills, students can analyze to make choices and provide conclusions so that their knowledge increases (Carillo et al., 2005). These skills can encourage students to express systematic ideas, develop argumentation skills, and make students active during the learning process (Hasani, 2016; Rivard & Straw, 2000). The following writing and referencing rules are to be taken into consideration.

Learning activities can teach writing skills by applying practical exercises about science. Practicum activities in science and the task of writing scientific reports are profound learning experiences. Students can analyze data and make relevant conclusions, so students act like scientists. Writing practicum reports can teach critical thinking skills, enhance conceptual understanding, and help students develop writing skills (Graham & Perin, 2007; Hand & Prain, 2002; Song, 2014). Practical reports based on experimental activities can be used as a valuable data source to determine the extent to which students are proficient in practicum activities, scientific reasoning, and inquiry skills used to complete the task of writing reports. Thus, practicum reports can be used as a communication media for science and learning tools to build student knowledge (Timmerman et al., 2011; Yore et al., 2002). Through writing activities, students become more fully aware of the subject matter. Besides being beneficial for students, writing skills are also necessary for teachers to provide information about student understanding and achievement of learning indicators. Previous study states that writing is an instrument teacher can use to determine how much students have learned and evaluate their academic performance (Sedita, 2013).

Scientific writing skills are challenging to teach students only through memorizing activities. Also, previous study state distribution of information from the teacher to students is not enough to solve a problem, Psaid that critical and reflective thinking must be provided for students to have good scientific writing skills (Kajal et al., 2011). Through writing activities, students will learn to apply, analyze, synthesize, and evaluate knowledge. However, physics learning often does not involve students in various activities, so students tend to be passive and use memorizing skills. These problems must be solved through learning about science, including by involving students in scientific writing activities (Erkol et al., 2010; Knowlton, 2001; Makrifah et al., 2017). Scientific writing skills can be developed by involving students in various learning activities in group and individual events. The study results show that learning involving inquiry processes can improve scientific writing skills because students document the findings of their thinking in writing and combine the results of their reflection in the form of reports at the end of learning (Aktaş & Ünlü, 2013; Dispriyani et al., 2015). The results of the research by previous study stated that the inquiry process was able to help students organize and analyze thought processes to train students to think in a structured manner (Gormally et al., 2009). With inquiry learning, students play an active role in the discovery process by dividing a complicated scientific method. They are stimulated to solve problems through deeper thought processes, produce evidence-based arguments, and grow metacognitive abilities when writing conclusions (Kipnis & Hofstein, 2008; V. S. Lee & Ash, 2010; Pedaste et al., 2015). The results of these studies indicate that the inquiry process is one of the appropriate learning to improve scientific writing skills.

The results of several studies show that learning involving inquiry processes can help students develop their writing skills. But in implementing instruction, students often have difficulty carrying out inquiry learning because they are accustomed to traditional knowledge, so they are less able to control variables when carrying out practical activities about science. This condition can affect the quality of the experimental report because students do not understand the various things that must be written in the news and cannot support the theory based on the evidence obtained (Deiner et al., 2012; O. Lee et al., 2006; Sadaghiani, 2008). As a result, learning objectives are challenging because student learning attainment is not optimal. Therefore, it is necessary to develop a media that can help students focus during education to alleviate the difficulties experienced by students. The assistance that the teacher can give to overcome student difficulties during the discovery process is by providing the scaffolding that can guide students to write scientifically. This assistance will be reduced as the ability increases until the aid is removed if the student has completed the desired ability. Appropriate scaffolding and focus from time to time during inquiry learning are effective in helping students become comfortable with inquiry learning and positively influencing the achievement of physics learning outcomes (Bautista, 2013; Williams et al., 2017). Besides, scaffolding can stimulate thinking processes in solving complex problems (Asy'ari & Ikhsan, 2019; Bradley et al., 2008). The results of the study suggest that students who are assisted in the form of guided questions can be helped so that they grow their critical thinking skills which involve the process of analysis, articulation, justification, and reflection (V. S. Lee & Ash, 2010). The application of

scaffolding in inquiry activities can help students focus more on writing experimental reports about science because students will only enter the information needed through the framing provided (Deiner et al., 2012; Gobert et al., 2018). One type of scaffolding that can be given is a prompting question presented as a worksheet as long as students carry out the inquiry process. Previous study state that the prompting question could facilitate the summing up of students by activating prior knowledge and mapping problems to existing problem schemes (Xun & Land, 2004). Applying a scaffolding prompting question on a worksheet in inquiry activities is expected to help students focus more on writing laboratory reports because students only enter the information needed in the news through the scaffolding provided. Based on the description above, scientific writing is essential for students in physics learning. However, there are some obstacles when education is conducted through inquiry processes. For this reason, the scaffolding prompting questions in the inquiry process needs to be tested in physics teaching in the classroom. Therefore, researcher intend to conduct research to analyze the effect of the scaffolding prompting question on scientific writing skills of high school students when inquiry physics teaching is implemented in the classroom. This study analyze the role of scaffolding, formulated as guiding questions in helping students develop scientific writing skills.

2. METHOD

This type of research is a quasi-experimental design with a post-test-only control design. In this design, the researcher set the control group and the experimental group, then gave treatment to the experimental class and gave a post-test to assess the difference between the control class and the experiment. The study was conducted in the senior high schools in Jember district, East Java province, Indonesia. The class level used for the research is class XI. The research area was chosen based on the specific objectives and considerations of the researcher. The determination of samples for the control and experimental classes in this type of research is not carried out randomly because this can interfere with classroom learning (Creswell, 2015). Sampling is carried out by purposive sampling, which is done by taking the subject rather than based on strata, random or regional but on the existence of specific objectives. Science learning in the experimental class was carried out with guided inquiry learning assisted by a scaffolding prompting question. In contrast, the control class was conducted with a guided inquiry model without scaffolding. During the implementation of instruction, students carry out the discovery process through practical activities on static fluid topics which are held for three meetings. Practicum is carried out in groups with four children in each group. Students write their findings in a worksheet given and assessed as a lab report at each meeting. Students write individual lab reports. Post-test is a measurement of a variable that an experimental participant assesses after a treatment has been carried out. Post-tests in the form of practicum activity at the end of learning activities can be used to determine the extent of the effects of treatment. The difference in post-test between the experimental and control classes can be used to describe the impact of treatment (Creswell, 2015; Mustofa & Hidayah, 2020).

The scientific writing was scored according to the scientific writing skills rubric developed by Grimberg & Hand (2009). Practicum is carried out in every lesson for three meetings, and scientific writing data is obtained from the final value of the lab report in the post-test session. The information on scientific writing skills from the post-test is then processed and analyzed based on the research objectives. The analysis technique used to treat the data in this study is the normality test and hypothesis testing with the Independent Sample t-test. A normality test is done to determine the distribution of standard data. The analysis is carried out using the SPSS program, a test with Kolmogorov-Smirnov where if the significance value is above 0.05, then the data is usually distributed. If below 0.05, then the information is not normally distributed. If the data has been normally distributed, then the t-test is then carried out by the Independent Sample t-test.

3. RESULT AND DISCUSSION

Result

Data on scientific writing skills are obtained from the assessment of worksheets written the inquiry learning process in the post-test. Worksheets are used as student lab reports which are assessed based on indicators of scientific writing skills. Learning is carried out three times the lesson with the first meeting is the submersion of the hydrostatic pressure, the second meeting of the Pascal law submission, and the third meeting is the law submission of Archimedes. Learning is carried out in 2 x 40 minutes at each meeting. At each session, students write a practicum report. The assessment of students' scientific writing skills is based on nine indicators; observation, comparison, analogy, clarification, statement,

cause/effect, generalization, deduction, and investigation design induction. After three times the lesson, students conduct the practicum activity in the post-test section. From the post-test, the final score on the indicators of scientific writing skills in the experimental and control classes is shown in Table 1.

Table 1. The Final Score of Each Indicator of Scientific Writing Skills

Indicators of Writing Skills	The final score of the experimental group	The final score of the control group
Analogy	80.86	62.04
Clarification	87.96	52.47
Claim	87.96	51.54
Observation	90.43	83.64
Causality	89.20	51.23
Compare	71.60	49.69
Generalization	66.98	13.58
Deduction	75.00	49.07
Design of Investigation	75.00	48.15
Mean	80.56	51.27
Standard of Deviation	5.50	6.80

Based on Table 1, it is known that the average score of all aspects of writing skills in the experimental class is higher than the control class, which is equal to 80.56 for the experimental group and similar to 51.27 for the control group. The final score of the highest scientific writing skills in the experimental and control classes is in the aspect of observation, which is equal to 90.43 in the experimental group and 83.64 in the control class. The lowest score lies in the element of generalization induction, which is 90.43 for the experimental group and 13.58 for the control group. The score of scientific writing skills is then analyzed using the t-test with the help of SPSS 23 to determine whether or not the influence of the scaffolding prompting questions in inquiry learning on scientific writing skills. The results of the Independent Sample T-test analysis are shown in Table 2.

Table 2. The Independent Sample t-test Results on the Score of Scientific Writing Skills

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	2.369	0.128	20.051	70	0.000	29.28667	1.46063	26.37354	32.19980
Equal variances not assumed			20.051	66.986	0.000	29.28667	1.46063	26.37123	32.20210

Based on the results of the analysis in Table 2, it can be seen that the value of Sig. the Levene's test is 0.128. Then, it can be concluded that data on scientific writing skills are homogeneous because the Sig value is more than 0.05. Analysis of the independent sample t-test can be seen in equal variance assumed with a Sig (2-tailed) value of 0,000. Because the study uses the proper hypothesis testing, the significance value (2-tailed) is divided into two and obtained (1-tailed) significance of 0.000. This value is less than 0.05 or 0.000 < 0.05, so the decision that can be taken means that scientific writing skills in the experimental group are different from the control class. So, it can be said that the scaffolding prompting question in inquiry physics learning influences scientific writing skills.

Discussion

The results of the data analysis correspond to the understanding and purpose of giving scaffolding. Previous study states that scaffolding assists and guides students during the early stages of learning (Moreno, 2009). Then children take on greater responsibility after they can complete it. According to previous study scaffolding can help students with difficulties in learning, for example, (1) sequencing tasks from the most comfortable levels gradually to high standards, (2) guiding each part of the scientific explanation, (3) providing advice to assist students and monitor their progress, (4) provide specific instructions to guide students to ignore irrelevant variables (Songer et al., 2013; Tegeh et al.,

2021). One type of scaffolding, for example, is giving guiding questions that help students learn to develop thinking skills in the form of a scaffolding prompting question. Meanwhile, inquiry learning is one of the active learning approaches to encourage attention, participation, and motivation and help students understand the topics being studied. The inquiry process consists of formulating problems, formulating hypotheses, collecting data, testing ideas, and drawing conclusions. The steps in inquiry learning correspond to objective writing indicators, so inquiry learning can be used to practice scientific writing skills. The implementation of inquiry learning can be maximized if accompanied by teacher guidance to assist students so that they focus more on education.

The prompting question applied in this study includes several, namely procedural, elaboration, and reflection. Each clue provides different cognitive and metacognitive goals. Procedural prompts are designed to help participants complete specific tasks such as writing or problem-solving. Some examples of the procedural prompt are "Examples of this ... ..." "Another good reason ...." Elaboration prompts are designed to encourage students to articulate thoughts and obtain explanations. Some examples of elaboration prompts are as follows: "What is a new example of ..." "Why is this important?" Influencing ... ". previous research shows that elaboration encourages critical responses and high-level thinking, thus effective in facilitating the construction of knowledge from various age groups (King, 1992). Reflection prompts encourage reflection on meta-levels where students generally don't realize it. Other study found that reflection prompts help students to integrate knowledge in science and guide students to solve problems such as planning, monitoring, and evaluation (Davis, 2000). The prompt reflection example is "to do this task well; we need to ...". Procedural instructions given in the prompting question can make it easier for students to change scaffolding answers into scientific writing because they help participants complete particular tasks such as writing or problem-solving.

This experimental research aims to analyze the effect of the scaffolding prompting questions in inquiry learning on scientific writing skills. During the learning process, students carry out practicum work in groups, writing the reports on individual worksheets. The worksheet is accompanied by scaffolding prompting questions on the subject matter of physics about static fluid. Worksheets help facilitate students in the learning process and practicing scientific writing skills about physics. The sheet contains a scaffolding prompting question that guides students to write by answering existing questions to help students construct knowledge that is manifested in writing on a worksheet as a lab report. Scaffolding assists students produce well-organized experimental reports and also teaches students about cognitive strategies from inquiry activities and scientific writing preparation (Bauer & Booth, 2019; Deiner et al., 2012). The scaffolding prompting questions on the worksheet contains indicators of scientific writing. At the same time, the worksheet components are identifying problems, formulating problems, submitting hypotheses, experimental steps, analyzing data, drawing conclusions, and designing advanced experiments. Student activities during carrying out the inquiry process and writing the results in the report guided by scaffolding are explained in the following sections.

The first indicator of scientific writing is analogy and clarification. Based on the results obtained, the final score of scientific writing skills in these aspects is included in the high category, equal to 82.86 in the analogy aspect and 87.96 in the element of clarification. The final score of the experimental class was higher when compared to the scores in the control class, which achieved a final score of 58.33 in the analogy aspect and 45.06 in the clarification aspect. These results are obtained because a daily life problem is presented to be solved by students who are explicitly written on worksheets. The spreadsheet contains a question about life around students so that it directs student focus and helps students make the appropriate problem formulation. Based on the problem identification activities, students are assigned to write down the background of the problem and formulate the question. The context of the problem is an analogy aspect, while the problem statement is an aspect of clarification. Students must write a problem statement in the form of questions that are used as a reference for conducting experiments and drawing conclusions at the end of inquiry activities. When writing the background and formulating the problem, students are helped to use scaffolding in the form of questions with short answers that help students identify issues in the problem identification section.

In the next step, students write hypotheses by formulating the problem that was written in the previous stage. The wording of hypotheses is the initial stage that helps students reason to find quick answers that correspond to the problem statement. The premise is an initial statement whose validity is unknown. In this aspect, the achievement of writing skills in the experimental class was 87.96, while in the control class, it was 62.35. This result shows that skills in claims have changed after being given scaffolding. By carrying out the inquiry process, students gather evidence to determine whether the hypothesis is accepted or rejected. At the observation stage, students collaboratively in groups conduct experiments and collect data according to the practicum steps. After getting the data, students write it into the experiment table. Based on the results obtained, the scientific writing skills in this aspect are high. The

final score of the experimental group was 88.89, while the control class was 82.72. This result shows that worksheets containing work steps and clear observation tables can facilitate students in the discovery process so that they get complete knowledge.

The next aspect of scientific writing is cause/effect, carried out by conducting data analysis activities. Students analyze data based on experimental results. The results of data analysis are written in paragraphs with appropriate reasoning to support the statement. Students write data analysis assisted with questions with short answers, then describe them again in sentences until they get sections with relevant evidence and explanations. The existence of a scaffolding prompting question can help students to focus on things that must be written accompanied by sufficient reasoning for the statement written. The assistance had an impact on the results of writing skills on aspects of cause/effect; students in the experimental class achieved the highest score compared to other elements, which amounted to 89.51. Different results were obtained in the control class; the final score was 52.78. These results indicate that the scaffolding prompting question is very helpful for students to explain the cause and effect of science. This study's results align with the statement of previous study that found scaffolding can help students associate key questions with certain parts of laboratory reports (Deiner et al., 2012). The scaffolding in the form of guiding questions can be used to determine various ideas, claims, and arguments so that they become part of the writing in the report. Students are also tasked with making generalizations or linking material to various examples of everyday phenomena accompanied by logical reasoning. In generalization induction, the score was categorized as the lowest compared to other aspects of scientific writing, but in the experimental class, it was still higher than the control class. This result is because the worksheet used in the experimental class is inquiry-based; some steps must be followed while carrying out the practicum and writing the report as guidance. Indicators of generalization induction do not enter the worksheet levels explicitly but come into the analysis section, so students tend to ignore the reasoning components. This result corresponds to the statement of other study that inquiry-learning practicum reports can be used to assess reasoning skills (Timmerman et al., 2011).

At the data analysis stage, students describe the graph as a form of related aspects to find out the relationship between variables. In defining the chart, students are helped by scaffolding to graph the relationship correctly and explain why relationships occur between variables using answers in frame. In this aspect, the final score of scientific writing skills in the experimental class was 72.22, higher than the control class of 49.69. The score is included in the low category compared to the scores achieved on other scientific writing indicators. The low score occurs because most students draw various variables in one graph without writing down the measurement data. Also, in buoyancy style practicum, the volume value should be obtained by calculating the difference in the volume of water after the object enters the vessel, but most students use the final volume data rather than the difference in volume, so the data used to draw graphics is incorrect. Previous study state that the aspect compare is the most complicated part of scientific writing (Grimberg & Hand, 2009). The results of interviews with students stated that representing graphics is the most challenging piece of scientific writing. The ability to render graphics must be associated with understanding mathematically based on algebraic rules or specific formulas. The learning process involving various verbal and visual representations can produce better construction and information storage than just verbal learning (Anagnostopoulou et al., 2012; Rogowsky et al., 2015). Thus, describing the graph must be taught to students more specifically and sustainably so that students are accustomed to improving their skills in describing the chart.

The final stage of inquiry activities is concluding. Previous study state that conclusions are the reasoning stage connecting general ideas to specific claims (Grimberg & Hand, 2009). Findings must be used to answer the formulation of problems written at the beginning of inquiry activities. Through the stages of inquiry, students can make the final wording of the concepts learned. With the help of scaffolding, students can conclude and answer the problem formulation appropriately. During this time, students tend to have difficulty making conclusions because they do not understand the content and purpose of the findings. With scaffolding, students are helped to write conclusions appropriately (Supeno & Maryani, 2019; Vale et al., 2019).

The final part of inquiry activities is writing advanced investigation designs. Students are helped with problems so they can design according to the answers to these problems. These problems can guide thinking processes and help students focus on the topic delivered by the teacher. The task of designing advanced investigations is aimed at making students skilled in developing experiments as a follow-up activity for the concepts that have been obtained during the previous inquiry process. The final score in this aspect is 76.23 in the experimental class and 53.70 in the control class. Compared with the value of other issues of scientific writing skills, the achievement of the score is included in the low category. The low rating achieved is because most students tend to focus more on answering the problems presented through their knowledge without a practical design. This result is in line with the statement of that the

design of advanced investigations is a complicated cognitive activity because it requires the identification of effects with acceptable evidence (Grimberg & Hand, 2009). Students are expected to be able to integrate questions and claims and produce conclusions. The results of the study show that the scaffolding prompting question can be used to help students improve their scientific writing skills. Scaffolding assists students in achieving the desired skills. Students can express the frame of mind that must be written in the lab report with the help of a scaffolding prompting question.

The results of scientific activities through the inquiry process can be compiled in written form. Scientific writing can be structured based on the help of answers to the questions asked. Previous study state that the prompting question can facilitate concluding by activating prior knowledge and mapping problems to existing problem schemes (Xun & Land, 2004). The scaffolding prompting question also directs communicative goals more clearly where students enter the necessary and appropriate information into their reports (Davis, 2000; Supeno & Maryani, 2019). It can be said that giving a prompting question can help students build complete knowledge. The implication of this study are providing overview related to the effect of scaffolding prompting questions on scientific writing skills in the inquiry classroom. It can lead students to write scientifically. Based on the results of this study, several suggestions can be proposed for researchers and education practitioners. This research can be continued by providing a scaffolding design to teach aspects of scientific writing, especially on induction generalization and graph drawing. Scaffolding prompting questions is also recommended to be applied to learning for the subject matter of other physical problems.

4. CONCLUSION

The scaffolding of the prompting question in inquiry learning significantly affects the scientific writing skills of high school students. Scaffolding prompting question helps students assist students in compiling a frame of mind and describing it in complete writing in the lab report. Writing as a complicated skill for students can be developed by providing inquiry-based science learning activities. The results of the inquiry process can be formulated in a structured written form by writing following the instructions in the form of questions.

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