
Implementation of Practicum Worksheets Based on Guided Inquiry on the Topic of Colloids to Improve Students' Science Process Skills

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Abstract. Currently, a lot of learning focuses on cognitive achievement, which results in less involvement of students in learning. Whereas in the renewable curriculum students are required to have ability incognitive, affective and psychomotor. One of these psychomotor aspects is science process skills by applying inquiry model. This study aims to determine the effect of the implementation of guided inquiry-based practicum worksheets on colloid topics on students' science process skills. The research method used mixed research method research with concurrent triangulation designs. The research was conducted in Cimahi, involving 33 students of class XII and 5 validators consisting of two lecturers and three teachers. The research instruments were used self-assessment, observation sheets for practicum activities using guided inquiry-based worksheets, assessment of student worksheet's assignments, and restricted-response essays. The enhancement of science process skills was calculated by the N-gain formula using pretest and posttest score and characterize into high, medium and low. The results showed that the improvement of student science process skills on the topic of emulsifiers was in the medium category with an N-gain value of 0.6. The implementation of the practicum using guided inquiry-based worksheets on the result of self-assessment obtained 82.0%, the results of observation obtained 82.9%, and the assessment of student's assignment in the worksheets obtained 81.6% in which all in the very good category.

Keywords: colloid, guided inquiry-based worksheet, science process skills

Introduction

Nowdays, a lot of learning focuses on cognitive achievement and still focused on the teacher, which results in less involvement of students instudying (Hong et al., 2017). Whereas in the renewable curriculum students are required to have skills in cognitive,

affective and psychomotor. One of these psychomotor aspects is science process skills by applying inquiry model, where not only science process skills can be improved, but also cognitive aspects. The inquiry learning model is a learning activity that emphasizes the development of inquiry skills and thinking habits that enable students to continue the search for knowledge. The main goal of classroom-based inquiry learning is to allow students to design their own experiments, collect data from the experiments, interpret the results, justify the conclusions with the results, and communicate the results of the experiments to others (Teig et al., 2018). The curriculum 2013 has purpose to prepare Indonesian students have ability as individuals and citizen who are faithful, productive, creative, innovative, affective, and able to give contributions to society, nation, state, and world civilization. The target of learning process in the curriculum 2013 is develop 3 domain competences which are knowledge, attitude, and skill. To achieve these goals, curriculum 2013 gives recommendation to apply scientific in the learning process. The contents of curriculum 2013 certainly followed the needs of student in this era when they contribute in society and looking for a job. Besides that, the outcome is the 21st century skills in the form of high order thinking skills such as analytical, creative, critical, and innovative (Kemendikbud, 2016). A good curriculum will not be able to achieve its goals if it is not supported by a good learning process. Permendikbud No. 22 of 2016, states that the implementation of inquiry or discovery learning can be solution to strengthen the scientific approach or integrated thematic. Arrends said that inquiry learning involves students to search, investigate systematically, critically, logically, and analytically.

The implementation of inquiry learning gives student have an experience to find the truth about a concept and draw conclusions (Kuhltlau, 2010). Moreover, it was stated that among the many teaching methods, inquiry-based teaching is considered to be an effective way for students to learn and solve problems on their own (Jing-Yun Fan & Jian-Hong Ye, 2022). At the same time, inquiry-based learning helps learners develop the ability to work in complex and unpredictable environments, enabling them to become more critical thinkers and active learners (Suarez et al, 2018). Trowbridge & Bybee (1996) states there are three kinds of inquiry learning models, those are free inquiry, guided inquiry, and structured inquiry. There were several argument about the sequences of inquiry learning models, namely: includes questions, observation, doing, and explanation, and other processes (Yang et al. 2021). Another model approach which includes questions, collection/analysis, discussion, explanation, amendment, and confirmation (Hong et al, 2019). But, between those three, guided inquiry is the type of models that is suitable to be applied in SMA/MA level. It is because in guided inquiry students are able to understand the concept and have ability to think concretely and abstractly, but their psychological condition is not stable therefore they still need guidance from the teacher to carry out this stage. Applying guided inquiry learning, need a method that can support the learning.

One of the appropriate methods for implementing guided inquiry is practicum method. By doing practicum method, students get experience to test hypotheses, design, conduct,, collect data, analyze data, interpret data, and conclude data by doing experiments (Salbiah, 2017). Applying the guided inquiry learning model with practicum method can also develop science process skills. According to Ministry of Nation Education (2008), worksheet gives chance for students to play an active role in the learning process and discover concepts through science process skills. Furthermore, inquiry-based learning can be used as an approach that allows students to conduct their own scientific experiments to construct knowledge, rather than acquiring new knowledge directly from the teacher's lecture process (Jerrim, at al., 2020)

Science process skills are a set of that use by scientist to do scientific investigations. Science process skills include state a problem, collecting information that relate to the

problem, making assumptions, controlling variables, conducting experiments, taking measurements, making inferences or predicting, collecting and processing data from observation, drawing conclusion, and communicating (Kemendikbud, 2016), in which it can makes a connection between the activity that elicits interest and positive feelings, this makes us want to repeat the behavior (Bressler et al., 2021). In addition, students are also be able to understand the concept better. This result is in line with the opinion expressed by Kurniati (2001) which states that through science process skills, students are given opportunity to find facts, build concepts, and carry out activities like a scientist. It can help students to develop their knowledge and skills how to work systematically and increased a great interest in learning that can support to success in a variety of domains (Zheng, 2021). In Permendikbud No. 37 of 2018 on basic competencies 3.14 and 4.14 talk about colloid material which has quite a lot of materials.

The topic of colloids is one of the chemical concepts that explains natural phenomena and is often used in daily life. Research conducted by Nurul (2021) shows result that the learning process of colloid material in class, students are only introduced to the material through Power Point presentations or learning videos then students are asked to study it by themselves so that students' ability to understand concepts is not honed. Whereas the topic of colloids needs to be explored by students by constructing their knowledge with the help of the teacher. The teacher is only a guide and facilitator give border to students not to learn things out of the material that should be taught, because of there are demands from the 2013 curriculum that wants the development of students' abilities in process skills and scientific attitudes, these two things also need to be applied in learning. Therefore, researchers want to apply guided inquiry-based worksheets entitled "The Uniting of Water and Oil" to find out the improvement of students' science process skills on the topic of colloids in classroom learning.

Methods

The research method used in this research is mixed method. According to Cresswell (2014), mixed methods research is research approach that combine qualitative and quantitative methods. The research design used is concurrent triangulation designs. In the concurrent triangulation design, the researcher collects quantitative and qualitative data at one time, then the researcher compares two data to determine whether there is convergence, difference, or some combination. The notation with concurrent triangulation research design can be written qualitative+quantitative or quantitative+qualitative. The research conducted in SMA Negeri 5 Kota Cimahi. Where sampling is done randomly, which represents students who have studied colloids. The subject of the research is 33 students of class XII who took part in learning colloid material. Students were divided into six groups with each group consisting of 5-6 students chosen randomly. This research also involved five expert validator which are divided in two lecturers and three school teachers.

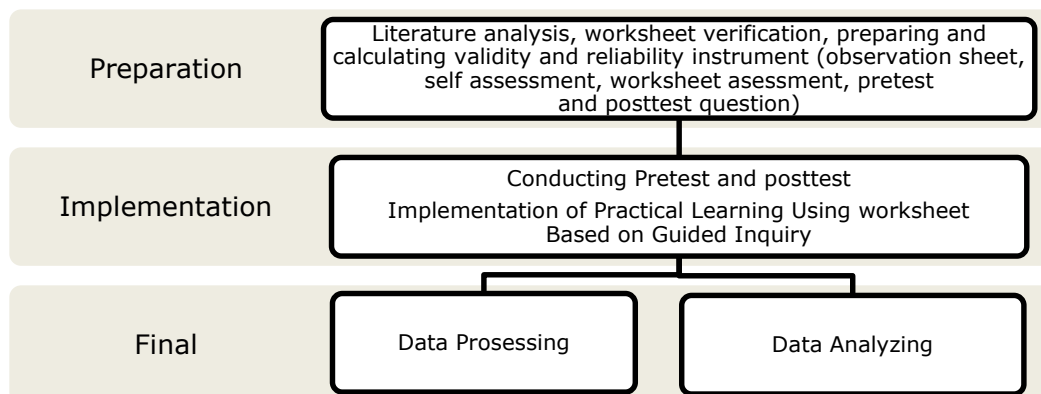


Figure 1. Research flow implementation of guided inquiry-based practicum worksheets.

Data collection and analysis is carried out systematically as shown in Figure 1, where this process goes through three main stages, including the preparation, implementation and final stages. The pretest and posttest score are analyzed by calculating N-Gain using this formula:

$$N - gain = \frac{\text{Posttest score} - \text{pretest score}}{\text{Maximum score} - \text{pretest score}}$$

The N-Gain value characterizes analysis using the criteria in Table 1. While the reliability is calculated using statistical package for social science (SPSS) version 20.0 software research flow with internal consistency method and Cronbach alpha technique.

Table 1. *N-gain value criteria*

Nilai <i>N-gain</i>	Criteria
$N-gain \geq 0,7$	High
$0,7 > N-gain \geq 0,3$	Middle
$N-gain < 0,3$	Low

(Sumber: Hake, 1998)

Results and Discussion

The first instrument that is used to see the implementation of the guided inquiry worksheets with practicum method is self-assessment. The use of this instrument is to give a judgement to the process with the guided inquiry learning worksheet by students. Figure 2 is a graph of score of self-assessment on the implementation of guided inquiry worksheets with practicum method. In this step teachers participate in learning because it can be encouraged active discussion among students during lessons can enhance students' higher levels of cognition (Dubey, et al., 2017).

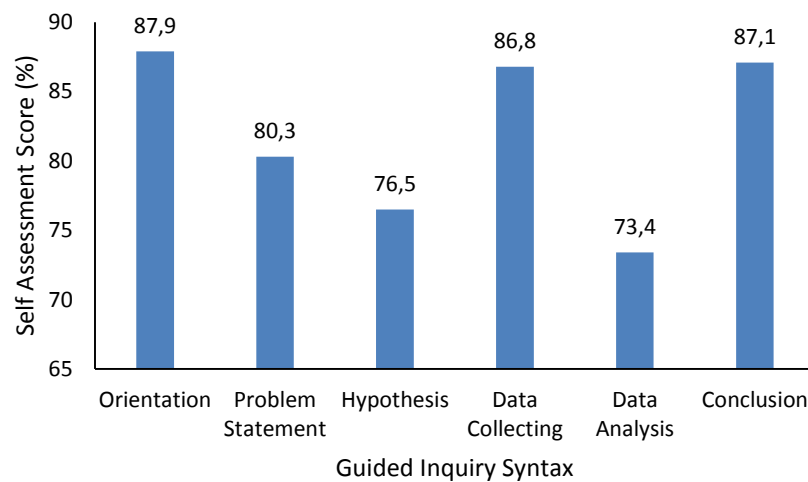


Figure 2. The self-assessment of practicum implementation using guided inquiry results graph.

The second instrument used in this research is observation sheet. The using of this instrument is to give judgement toward guided inquiry syntax that have been done by the students during the learning process. Figure 3 is graph of score of observation sheet on the implementation of guided inquiry worksheets with practicum method.

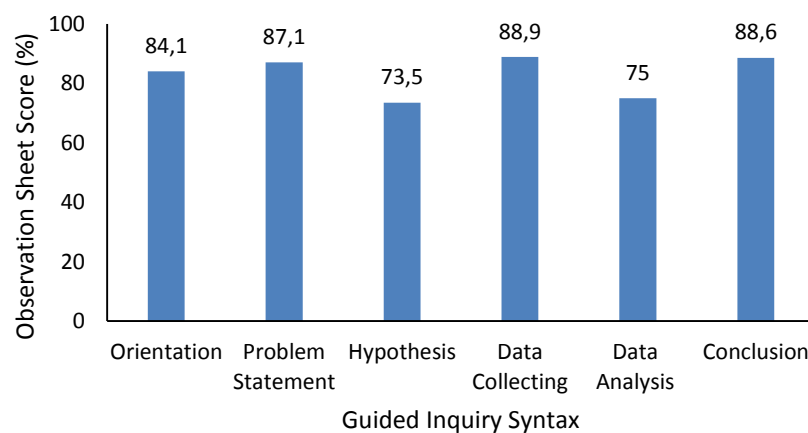


Figure 3. The observation sheet of practicum implementation using guided inquiry results graph.

The third instrument that used in this research is rubric for assessing student's answer to assignments in worksheet. The tasks that contained in the worksheet consist of syntax of guided inquiry which were developed including: at the orientation stage, students are required to read the text about phenomena that relate to colloid and write down the important information based on the text, at the stating problem stage, students are instructed to write down some question that relate to the phenomena and choose one of those question that become the focus of the practicum. At formulating hypotheses stage,

students predict the result at the end of practicum to answer the question that have been state at the previously. At the collecting data stage, students are asked to determine the title of the practicum, purpose of the practicum, tools and materials needs for the practicum, arranging procedures, determine the variables, writing data and observations, and analyzing the data by answering eight questions that will direct students to find the concept, stage testing hypotheses and stage of drawing conclusions. Figure 4 is a graph score of student's answer towards assignments in the worksheet.

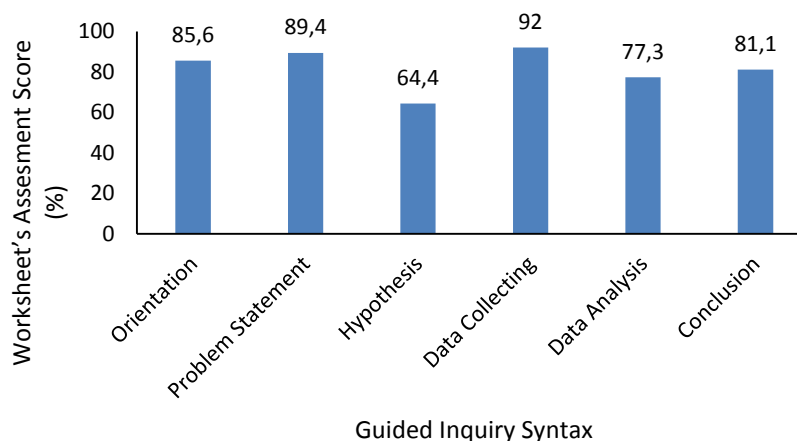


Figure 4. The worksheet assessment of practicum implementation using guided inquiry results graph.

Based on analytic result of those three instruments, the average score at each stage of inquiry is presented in the following Table 2.

Table 2. Score of Each Guided Inquiry Syntax

No	Guided Inquiry Syntax	Score of Each Guided Inquiry Syntax (%)			Average (%)
		<i>Self-Assesment</i>	Observation Sheet	Worksheet's Assesment	
1	Orientation	87,9	84,1	85,6	85,9
2	Problem Statement	80,3	87,1	89,4	85,6
3	Hypothesis	76,5	73,5	64,4	71,5
4	Data Collecting	86,8	88,9	92,0	89,2
5	Data Analysis	73,5	75	77,3	75,3
6	Conclusion	87,1	88,6	81,1	85,6
Average					82,2

From Table 2 we can know that the overall implementation of the guided inquiry worksheet with practicum method has been carried out very well with score 82.2%. The largest score was obtained at the stage of collecting data with a score of 89.2% while the smallest score was obtained at the stage of formulating a hypothesis with a score of 71.5%. In the first stage, namely orientation stage, students are asked to write down some important information listed on the phenomena that exist in the worksheet. From the results of the analysis obtained an average score of 85.9%. This shows that the orientation stage has been carried out very well.

The second stage is the stage of formulating the problem. Students are asked to write down several questions related to the phenomena in the worksheet. From the questions that have been written, students choose one question that becomes the focus of the problem and the answer will be sought through the practicum that will be carried out. At this stage, students experience quite a lot of obstacles. The difficulties experienced by students can be seen from their answers in the worksheet which are still inappropriate. Some students write answers that only focus on milk, which is a phenomenon that exists in the worksheet, for example, students write the question "why can the content of vegetable stabilizers can combine water and fat in milk?" even though it would be more appropriate to write a universal question, namely "why do emulsifiers can combine water and oil?". This matter causes wrong answer when students are asked to choose one question to become the focus of the problem. Although there are still students who are not quite right, the score obtained is 85.6% so that means this stage has been carried out very well. The third stage is formulating a hypothesis. At this stage, many students face difficulties. This is due to the lack of knowledge that students have about the topic of emulsifying substances, causing it to take a long time to complete this stage because students need to dig up information first from sources on the internet. In addition, based on the answers written in the worksheet, there were some students who wrote hypotheses that were not based on the question that has been made before. For example, the question that asked by students is "why emulsifier can unite water and oil?" but the hypothesis that is written is to answer the problem formulation "why water and oil can unite?". Based on the results of the analysis, for the stage of formulating the hypothesis, the score was 71.5%. This shows that the stage of formulating the hypothesis has been carried out well.

The fourth stage is collecting data. At the stage of collecting data, students are asked to write down the title of the practicum, the purpose of the practicum, the tools and materials used, the function of the tools used, the amount of material used, arranging experimental procedures, determining practicum variables, conducting practicum, writing down the data on the results of the practicum in the form of observation tables, and analyze the data by answering several questions related to the practicum carried out. At this stage, students have difficulty in arranging experimental procedures, determining experimental variables, and analyzing data. In the process of preparing the experimental procedure, many students made mistakes because they were not careful in reading the instructions in the worksheet. In the worksheet, the experimental procedures are written which are still not sequential, then students are asked to order them first for practicum. However, most students did not read the order and immediately did the practicum according to the sequence of procedures written in the worksheet. This causes students have to repeat the practicum so that it takes quite a long time.

For determining practicum variables, students are also not careful in reading the instructions in the worksheet. The variables that must be determined are control, dependent, and independent variables, so it still needed that appropriate instruction provided by the teacher during inquirybased learning improved student learning outcomes more than uninstructed or minimally instructed inquiry-based learning for the same course

material (Xenofontos, et al., 2020). In the worksheet, the choice of variables that must be written is given, then students just enter these choices into the appropriate variables. However, from students' answers in the worksheet, students write down the variables that did not match the choices that had been given. In addition, students are still unable to distinguish between control, dependent, and independent variables so it is necessary to explain slowly first so that students can complete the task. This also causes take quite a lot of time. In the data analysis section, students are asked to answer several questions related to the practicum being carried out. The difficulty experienced by students is the lack of knowledge about colloids and emulsifiers. This is because colloidal material in which the topic of emulsifying substances is contained in KD 3.14 class XI which should be studied at the end of semester 2 but in the reality, students only learn the material in a short time. This also causes the time required for students to complete this stage quite a lot because students need to find information first from sources on the internet. Although there are still difficulties, the stages of collecting data have been carried out very well with the acquisition of a score of 89.2%.

The fifth stage is testing the hypothesis. At this stage, many students also experience difficulties so that there are still errors in filling out the worksheet at this stage. From the answers written, students rewrite the hypotheses they wrote in the section on formulating hypotheses instead of answering "Are the results of the practicum obtained with the hypotheses that have been formulated appropriate or not?". Based on the results of the analysis, the overall score at this stage is 75.3%. This shows that the stages of testing the hypothesis have been carried out well.

The sixth or final stage is drawing conclusions. At this stage students do not experience difficulties but there are still students who answer wrongly in the worksheet. There are still some students who write conclusions but do not answer the question that has been made before. In addition, there are also students who write conclusions by rewriting the observational data obtained after doing the practicum. Nevertheless, this stage has been carried out very well with the acquisition of a score of 85.6%.

Based on the results of the analysis of the three instruments used, the obstacles or difficulties faced by students during learning by applying guided inquiry-based worksheets with the practicum method are the short duration of time that makes students learn about the material a bit in a hurry and the students' lack of knowledge of the material being studied. The improvement of students' science process skills was measured using a written test in the form of pre-test and post-test. The preparation of the science process skills test questions went through several stages, namely the preparation of the question grid, the manufacture of science process skills test items, the preparation of the answer key, and the quality test of the questions (content validity and reliability tests).

The pre-test and post-test questions are made based on the grid of questions that have been prepared. The test questions are in the form of limited description written test questions. The questions are arranged based on ten indicators of science process skills namely observing, classifying, interpreting, predicting, asking questions, hypothesizing, planning experiments, using tools/materials/sources, applying concepts, and communicating (Rustaman, 2005). The selection of science process skill indicators that will be developed is based on basic competencies and indicators of competency achievement in the chemical material. Based on this, 12 items were obtained that represent ten indicators of science process skills.

The items that have been made are then validated by 5 experts and tested for reliability. The content validity test was carried out by 5 validators with details of 2 lecturers and 3 high school teachers. Based on the results of processing the content validity that was carried out using the Aiken V coefficient, the instrument tested was feasible to be used

in learning with an overall score of 0.93. For the reliability test, it was processed using the SPSS software version 20.0 with the internal consistency method and the Cronbach Alpha technique. Based on the results of data processing, the reliability result is 0.75 so it is included in the reliable category because from the Cronbach's α (Hair et al., 2019) suggested that Cronbach's α should be higher than 0.70 to meet the acceptable standard. This indicates that the pre-test and post-test questions are acceptable and feasible to be used to test students' science process skills in learning by applying guided inquiry-based worksheets. The results of the pre-test and post-test were then processed so that the N-gain value was obtained which was used as an indicator of improving students' science process skills. The pre-test is carried out before learning by applying the worksheet, while the post-test is carried out after the learning by applying the worksheet is complete. Science process skills can be developed through practical activities that using worksheet because learning with practicum can provide opportunities for students to experience or do it themselves and can determine the problem, observe, analyze, hypothesize, carry out experiments, conclude, and apply the information they have according to their needs (Suryaningsih, 2017).

From these tests, the average pre-test and post-test scores for each indicator of science process skills are in Table 3.

Table 3. Pretest and Posttest Results for Each Science Process Skills Indicator.

No	KPS Indicator	Pretest average score	Posttest average score
1	Observe	0,27	3,12
2	Asking question	0,64	2,91
3	Hypothesize	0,45	2,12
4	Planning an Experiment	4,48	10,61
5	Using Tools/Materials	2,42	5,06
6	Grouping	8,52	10,36
7	Predict	0	3,76
8	Interpret	0	1,97
9	Applying the Concept	0,79	2,94
10	Communicate	0	3,39

The score of pretest and posttest are processed using the formula from Hake (Meltzer, 2002). Based on the calculation, N-gain from each indicator of science process skills were shown in Figure 5.

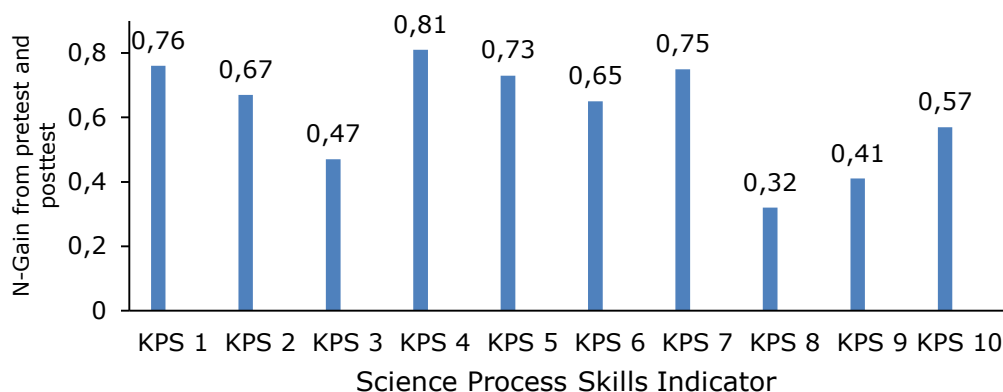


Figure 5. The N-gain value from pretest and posttest students' science process skills on each indicator.

Description:

KPS 1 : Observe	KPS 6 : Grouping
KPS 2 : Asking question	KPS 7 : Predict
KPS 3 : Hypothesize	KPS 8 : Interpret
KPS 4 : Planning an Experiment	KPS 9 : Applying the concept
KPS 5 : Using Tools/Materials	KPS 10 : Communicate

Based on the graph, it can be seen that the highest increase in the science process skill indicator based on the N-gain value is the indicator for planning experiments with an N-gain value of 0.81 while the science process skill indicator which has the lowest increase based on the N-gain indicator interprets the value. 0.32. In which during the investigation phase, students identify issues related to the problem by designing the investigation, conducting experiments, and interpreting and evaluating the results (Teig et al., 2018) The observing indicator obtained an N-gain value of 0.76 with an average pre-test score of 0.27 and an average post-test score of 3.12. This shows that before the implementation of the worksheet students have not been trained in observing a phenomenon or event using the five senses of sight but after the implementation of the worksheet students have experienced a high increase in skills so that it can be said that the application of worksheet based on guided inquiry is effective in improving students' observing skills.

The indicator asking questions has an N-gain value of 0.67 with an average pre-test score of 0.64 and an average post-test score of 2.91. This indicates an increase in students' asking questions, including in the medium category. Before the implementation of the student worksheets, students have not been trained in asking questions related to a phenomenon and after the implementation of the student worksheets, students experience an increase in ability in this regard, although not all students. In the pre-test and post-test, students were asked to formulate a problem statement in the form of a question that was in accordance with the experimental procedure that had been given. However, in filling it students are still not on target. This is because students are not used to determining the problems that will be tested in the practicum they do.

The hypothesized indicator obtains an N-gain value of 0.47 with an average pre-test score of 0.45 and an average post-test score of 2.12. This indicates that the increase in students' hypothetical skills belongs to the medium criteria. Before the implementation of the student worksheets, students have not been trained in making a hypothesis, but after the implementation of the student worksheets, the skills of making hypotheses have increased. This hypothetical skill improvement is still owned by only some students. This

is because students still do not understand how to make hypotheses based on the problems posed. Indicators asking questions and hypothesizing have a relationship between the two. According to Sanjaya (2006), to develop students' abilities in formulating hypotheses is to familiarize students with asking various questions so that they can stimulate students to estimate possible answers or find ways to solve a problem being studied.

The indicator for planning the experiment obtained an N-gain value of 0.81 with an average pre-test score of 4.48 and an average post-test score of 10.61. This indicates that students experience an increase in their experimental planning skills, which are included in the high category. Items related to planning experiments include preparing experimental procedures and determining tools. Before the implementation of the worksheet, some students were able to write down the tools needed in the practicum that would be carried out even though they could not write all of them, but after the implementation of the worksheet students were able to write down the tools used in full. Likewise, in the matter of preparing experimental procedures, before the student worksheets are applied, there are still mixed steps, but after the implementation of the worksheet students can write down the experimental procedures in the order they were written. This shows that the application of worksheets is effective in improving students' experimental planning skills. The indicator using tools/materials obtained an N-gain value of 0.73 with an average pre-test score of 2.42 and an average post-test score of 5.06. This shows that the improvement of students' skills on the indicators of using tools/materials belongs to the high criteria. Before the implementation of the worksheet, students were able to write down some of the functions of the tools they used and after the worksheet was applied the students could write down the complete functions of the tools used in the practicum. This indicates that the application of this worksheet is effective in improving students' skills in using tools/materials. The grouping indicator obtained an N-gain value of 0.65 with an average pre-test score of 8.52 and an average post-test score of 10.36. This shows that the improvement of students' grouping skills is included in the moderate criteria. Students already have basic knowledge of the material asked in the questions so that before the implementation of the worksheet most of the students were able to answer the pre-test questions correctly and after the implementation of the LKS, the students who previously had not answered correctly were finally able to answer correctly so it can be said that the application of this worksheet effective in improving students' grouping skills.

The indicator predicts obtaining an N-gain value of 0.75 with an average pre-test score of 0 and an average post-test score of 3.76. This indicates that the increase in students' predicting skills is included in the high criteria or in the other word, increased in cognitive aspect. In which this is relevant that inquiry teaching can produce positive cognitive and affective outcomes (Borovay et al., 2019). Before the worksheet was applied, students did not have the ability to predict but after the worksheet was implemented students could predict a phenomenon that would occur. In the instrument tested, students can predict what will happen based on pre-existing regularities. The indicator interprets the N-gain value of 0.32 with an average pre-test score of 0 and an average post-test score of 1.97. Based on this, it can be seen that the improvement in students' interpreting skills belongs to the moderate criteria. Before the implementation of the LKS, students did not have the ability to interpret so they could not answer the questions contained in the pre-test questions, but after the implementation of the worksheet, students began to have the ability to interpret although not optimally. Thus, it can be concluded that the application of this worksheet has not been able to effectively improve students' interpreting skills.

The indicator applying the concept obtained an N-gain value of 0.41 with an average pre-test score of 0.79 and an average post-test score of 2.94. Based on this, it can be seen that the improvement of students' skills on the indicators of applying the concept is

included in the moderate criteria. Before the implementation of worksheet students have not been trained in applying concepts and after the implementation of worksheet students have started to be trained but only for some students. This indicates that the application of worksheets is not effective enough to improve the skills of applying concepts to students. The communication indicator obtained an N-gain value of 0.57 with an average pre-test score of 0 and an average post-test score of 3.39. Based on this, the improvement of students' science process skills is included in the medium category. Before the implementation of the LKS, students did not have the ability to communicate but after the implementation of the worksheet students began to have the ability to communicate, although not optimally. In the instruments tested, communication skills were developed not verbally but in written form. Students change an observational data that is written in the form of long sentences in one paragraph into an observation table so that it is written shorter and easier to understand by others.

Based on these results, it can be seen that the application of the guided inquiry learning model can improve the ability of students' science process skills. This is in accordance with the results of research showing that there are significant differences in the improvement of science process skills between classes that using guided inquiry worksheets with classes that do not use worksheets guided inquiry (Saidaturrahmi, et al., 2019). Another research, conducted was found that there was significant difference in science process skills between the experimental class and the control class on material solubility and solubility product (Fitriyani, et al., 2017). The results of the analysis, it is found that the application of guided inquiry worksheets can improve students' science process skills with a coefficient of determination of 10%, it was relevant that inquiry on a practical curriculum can help students to find their own answers, correct misconceptions from mistakes, and then share what went wrong and how to improve (Newton & Tonelli, 2020), and support by (Mansour, 2015) noted that the value of inquiry-based learning for student learning and engagement in science classrooms is increasingly recognized.

Conclusion

The results of the implementation test of the implementation of guided inquiry-based worksheets on the topic of emulsifying substances overall obtained a score of 82.2%, with detailed of self-assessment 82.0%, observation 82.9%, and the assessment of student's assignment in the worksheets 81.6% in which all in the very good category. Furthermore The improvement of students' science process skills after the application of guided inquiry-based practicum is included in the medium category with an N-gain value of 0.6 are included in the medium category.

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