

# Potential of inquiry-based learning to train students' metacognitive and science process skill

*by* Insar Damopolii, Umar Keley, Devi Rianjani, Jan H. Nunaki, Elya Nusantari, Novri Kandowangko

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## POTENTIAL OF INQUIRY-BASED LEARNING TO TRAIN STUDENTS' METACOGNITIVE AND SCIENCE PROCESS SKILL

Insar Damopolii<sup>1</sup>; Umar Keley<sup>2</sup>; Devi Tutut Rianjani<sup>3</sup>; Jan Hendriek Nunaki<sup>4</sup>; Elya Nusantari<sup>5</sup>; Novri Youla Kandowanko<sup>6</sup>

<sup>1,2,3,4</sup>Universitas Papua, Indonesia

<sup>5,6</sup>Universitas Negeri Gorontalo, Indonesia

<sup>1</sup>Contributor Email: i.damopoli@unipa.ac.id

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### Abstract

The learning process in high schools in West Papua tends to focus on students' cognitive enhancement and ignore the aspect skill. School is the frontline to develop students' skills. Metacognitive and process skills are the two skills needed by the students, and both should be trained and developed. These two skills help students to implement an investigation process in which the investigation process can be well utilized using inquiry-based learning. This study aims to find out the differences in metacognitive and process skills between students treated with inquiry-based learning and those who are taught using conventional learning. This experimental study was carried out at Grade X of senior high school students of SMA Negeri 1 Manokwari. The result reveals a significant metacognitive skill of  $0.000 < \alpha < 0.05$ , and science process skill of  $0.001 < \alpha < 0.05$  of students who were taught using the inquiry-based learning more than those who were taught using the conventional learning. It can be concluded that there is a significant improvement in students' metacognitive and process skills for those who are taught using inquiry-based learning compared to those who are taught using conventional learning. Therefore, inquiry-based learning has the potential to appropriately train students' metacognitive and science process skill.

**Keywords:** Inquiry-Based Learning; Investigation; Metacognitive skill; Science Process Skill.



## A. Introduction

A learning process will be enjoyable when it is delivered using interesting methods. The classic verbal learning method is still one of the most implemented methods (Vácha & Rokos, 2017). Based on the observation, teachers in Senior High Schools in Papua Barat have designed learning based on the 2013 curriculum, yet, the implementation has not been as expected, and teachers are facing challenges in implementing this curriculum. Teachers focus deeply on students' cognitive assessment, whereas their skills assessment is yet to be carried out.

Even, the observation result also revealed that the average students' learning outcome in biology in one of the Public Senior high school in Manokwari was only 35.42 and in private high school was 53.45. It is clear from the data that students are yet to achieve success in learning. Thus, they need to be taught the skills to be successful in learning. It becomes even more urgent for students to be taught skills as the time now demands them to be prepared to compete globally. School is the frontline to develop students' skills. Metacognitive and science process skills are the two types of skills that need to be developed, especially in science classes such as, biology.

For students to appropriately accomplish their tasks, they need to be taught various skills, one of them is a metacognitive skill (An & Cao, 2014; Veenman & Spaans, 2005). Metacognitive skill plays a role in the students' success (Wang, Chen, Fang, & Chou, 2014). When students' metacognitive skills are developed, they will become good individuals and become active learners (Zull, 2012). Students will be able to understand a topic when they are involved in direct interaction with the environment where they obtain authentic problems (Lameras et al., 2014; Loyens & Gijbels, 2008).

Students' involvement with their environment can be carried out a thorough investigation. In this kind of investigation, science process skill is urgently needed. Science process skill is needed when students conduct an investigation (Damopolii, Hasan, & Kandowangko, 2015). It is clear here that investigation activity needs science process skills.

Investigation/research can only be properly carried out when students are actively involved in the investigation process. For this to happen



and for them to be able to accomplish their tasks, metacognitive skills are also needed to be developed. On the other hand, learning implementation in the classroom also influences students' success in learning. Appropriate learning is needed for biology class. Inquiry learning is an appropriate learning method that suits the characteristics of biology, learning that immerses students into authentic problems through investigation/inquiry process.

Exploration through nature observation needs to be taught to students (Ango, 2002). In the future, extensive research needs to be carried out to develop metacognitive skills in inquiry learning (Chen, Huang, & Chou, 2016; Hogan, Dwyer, Harney, Noone, & Conway, 2015; Sánchez-Alonso & Vovides, 2007). Where concepts can be easily understood, theorems can be mastered, and facts can be revealed through authentic inquiry activities in inquiry-based learning. Hence, students can become thinkers and this process will influence students' science process skills (Levy, Thomas, Drago, & Rex, 2013; Myers & Dyer, 2005; Yakar & Baykara, 2014).

Students' metacognitive skill is reflected in how they understand science, how they learn a concept in learning, and how they understand the concept within a topic taught by their teacher (Thomas, 2013). Science education aims to develop students' metacognitive skills (Zohar & Barzilai, 2013). Teaching methods employed by teachers influence students' metacognitive development (Case & Gunstone, 2002), and inquiry learning is one of the alternatives to develop students' metacognitive development. Students' metacognitive skill determines the increase in students' learning process within the class (Thomas, 2003). Meanwhile, in a biology lesson, science process skill (throughout this paper will be referred to as SPS) is a tool for students to carry out an investigation during the learning process. SPS can also be trained in inquiry learning.

Various studies have shown the influence of inquiry learning on students' metacognitive (Aswadi, Fadiawati, & Abdurrahman, 2018; Fitriana & Haryani, 2016; Fitriyani, Corebima, & Ibrohim, 2015; Hofstein et al., 2018; Nunaki, Damopolii, Kandowangko, & Nusantari, 2019) and science process skill (Audityo, Hairida, & Rasmawan, 2017; Budiyo, 2016; Damopolii, Hasan, & Kandowangko, 2015; Hardianti & Kuswanto, 2017;



Koksal & Berberoglu, 2014; Savitri, Wusqo, Ardhi, & Putra, 2017). Metacognitive helps students during an investigation (Bruckermann, Aschermann, Bresges, & Schlüter, 2017; Zhang, Hsu, Wang, & Ho, 2015). Zhang et al., (2015) in their study revealed that the analysis process in inquiry learning demands students' metacognitive skills.

This is shown that the metacognitive skill of the students is developing. Following the analysis, the last stage of inquiry is conclusion drawing, where the formulation of the conclusion is part of SPS. It is shown that inquiry-based learning has the potential to train students' metacognitive and SPS. The inquiry has a good influence on students' metacognitive (Nunaki et al., 2019). 16.48 % of metacognitive was influenced by inquiry learning (Muna, Haryani, & Susilaningsih, 2016). In this study, it was revealed that inquiry learning only provided a small contribution. Thus further development is needed. Studies Linanti, Anwar, & Santoso, (2017) showed that inquiry learning influenced metacognitive skills by an average of 51.1.

On the other hand, it was found that the effect of inquiry learning on SPS is 29.16 %. Similarly, Ogan-Bekiroğlu & Arslan, (2014) in their study on inquiry learning utilization in science class found that inquiry learning could better train SPS in science learning. In SPS evaluation, they used multiple-choice questions. We considered that a shifting paradigm is needed in measuring SPS on science learning. The essay test could be utilized to measure the SPS of the learners and it could better explore the SPS in learning. At the end of their paper, they suggested to use inquiry learning and to study the effects on students.

Different findings are by Campbell, Zhang, & Neilson, (2011) that on the first SPS test, students' in-group control on average obtained a higher score than SPS learners in experiment class (students who treated with the inquiry learning). On the second SPS test, the SPS of the learners in both groups were lower than the first test; however, on the third test, the result was higher than the first and second test. Nevertheless, their result showed that there were no significant differences in SPS between the two groups. They expected further implementation of inquiry-based learning to improve the learning process.



Based on the observation, results, and recommendations from previous studies, metacognitive skill and science process skills need to be trained to high school students in Manokwari by using inquiry-based learning. The research question in this study are: (1) are there any metacognitive differences between learners in inquiry-based learning group and those in the conventional learning group? And (2) are there any science process skill differences between the inquiry-based learning group and those of conventional learning groups? Therefore, this study will discuss the metacognitive and science process skills of students in inquiry-based learning.

## B. Method

This experimental research used the posttest-only control group design (Fraenkel, Wallen, & Hyun, 2011). It was conducted in the second semester in the academic year of 2017-2018 in the senior high school SMAN 01. In this study, 59 subjects were taken from grade X which consisted of 27 subjects from grade X2 (as the experiment group) and 32 subjects from grade X5 (serves as the control group). These subjects were selected using a purposive sampling technique.

The instrument to assess the metacognitive skill of the students was a 9-item descriptive question integrated into the learning outcome test. The Corebima rubric assessment was used to determine the level of students' metacognitive skills (Corebima, 2009). This rubric comprised of 8 levels of description to describe students' metacognitive skills. Each description had its score. The lowest score was 0, and the highest was 7. This rubric assessment comprised students' ability to answer the question, from unable to appropriately responds to the question, answering the question with their answer or not, the answer language was logically and systematically structured, and usage of several critical analysis to describe the answer.

To assess students' science process skills, descriptive questions were used. The science process skill was assessed using observation, formulating a problem statement, creating a hypothesis, assessing, communicating, and drawing a conclusion. The science process skill score range was from 0 - 4. The number of test items for this science process skill was six items.

Metacognitive test skill and science process skills were to be used following the validation from three experts. The validation result showed



that the metacognitive skill test score was 95.83% and the science process skill test score was 86.90%. The validation result of these two instruments showed that the instruments were valid and thus, can be used.

In classroom learning, the lesson plan used had a validity score of 97.69 % (valid), student worksheet validity score was 93.52 % (valid) student book validity score was 87.01 % (valid). The data analysis in the form of descriptive data by using achievement percentage and inferential analysis using an independent t-test to find out the differences between metacognitive and science process skills of the experiment and control groups. Prior to this, the least significant test, the prerequisite test: normality test through Kolmogorov Smirnov test and homogeneity test of the Levene test was administered.

### C. Finding and Discussion

#### 1. Finding

This study is aimed at finding out the differences between the metacognitive and science process skills of students who were taught using inquiry-based learning and those who were taught using conventional learning. The data presented below is the comparison of the metacognitive and science skill process skills of students who were taught using inquiry-based learning and conventional learning.

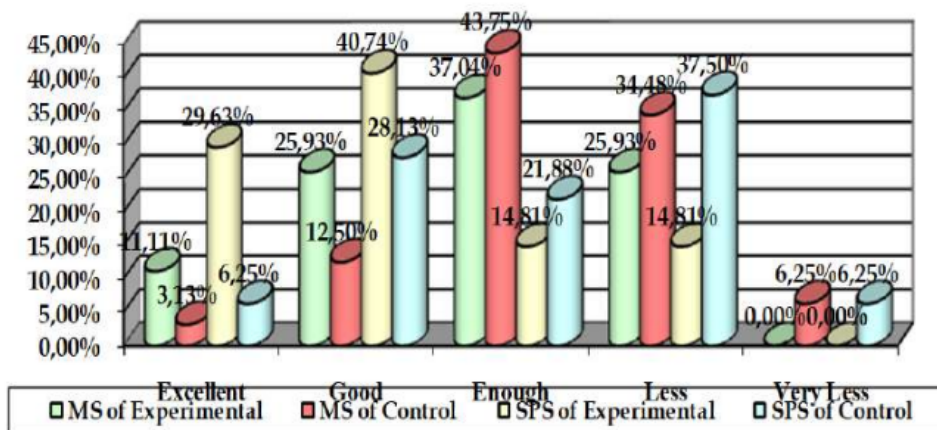


Figure 1. Comparison graphic of achievement percentage in metacognitive skill and science process skill



Based on Figure 1 above, it is found that the highest percentage of students' metacognitive skill achievement in the experiment group ranges from moderate to excellent by 74.01%. Whereas in the control group, regardless of the category, it is still moderate to excellent, the achievement in metacognitive skill was only 59.38%. In addition, in the low and very low category, the percentage in the experiment group was only 25.93%. This percentage is smaller than the control group score, which score was 40.63%. These percentage data showed that inquiry-based learning could train the metacognitive skill of the students compared to the conventional learning method.

Similar findings are also found in students' science process skills. The degree of metacognitive skill achievement is within good to the excellent category in the experiment group by 85.19%. The obtained score is larger compared to the percentage of achievement of students' metacognitive skills in the control group which was only 56.25%. On the other hand, in the low and very low category, the experiment group achievement was very small by only 14.81%, whereas in the control group the achievement was 43.75%. This data indicates that inquiry-based learning has the potential to train the science process skill of the students compared to conventional learning. The detail achievement for each indicator of science process skill in experiment and control groups is presented in Figure 2 below.

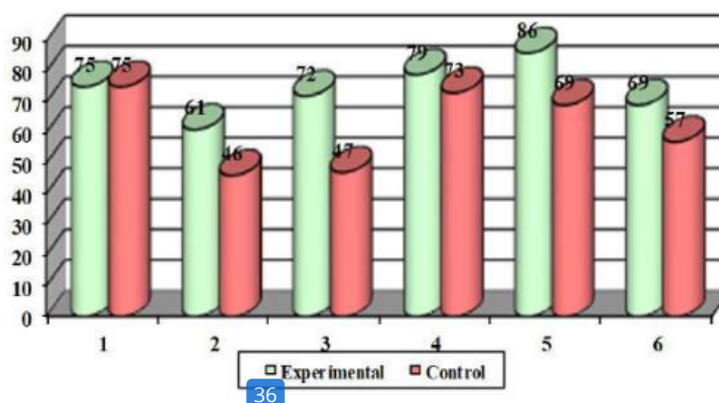


Figure 2. Comparison graphic of science process skill indicators: (1) observation; (2) formulating problem statement; (3) creating hypothesis; (4) measuring; (5) communicating; and (6) drawing a conclusion.





The data from the Figure 2 above shows that one of the indicators (communicating) in experiment group achieved a very good category, whereas, three indicators (observing, formulating a hypothesis, and assessing) were within a good category, whereas for two indicators, formulating problem statement and drawing conclusion was able to achieve an average category. Meanwhile, in control group, two indicators, observing and assessing achieved a good category, one indicator (communicating) achieved an average category, one indicator (concluding) achieved a low category, and two other indicators (formulating the problem statement and creating hypothesis) achieved a very low indicator.

Based on these data, it is found that students who were taught using inquiry-based learning their science process skills were better compared to the students who were taught using conventional learning. In inquiry-based learning, there was no excellent category as well as no low and very low category. Whereas, in conventional learning, there was no indicator with the excellent category; however, there were some indicators with a low and very low category.

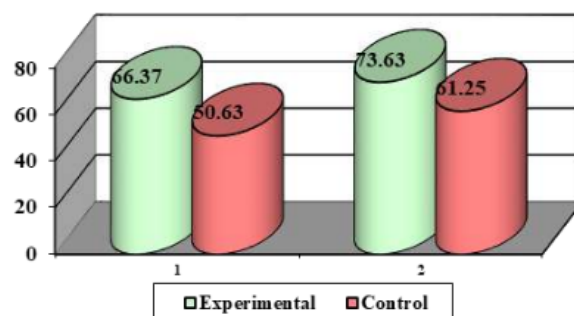


Figure 3. Comparative graphic of mean (1) metacognitive skill and (2) science process skill

Based on the <sup>10</sup> above figure, it is shown that the average metacognitive skill and science process skill between the experiment and control groups are different. The metacognitive skill of the students in the experiment group is only in the moderate category, nevertheless, this achievement is better than those who are in the control group, who only achieved a low category. This means that inquiry-based learning is appropriate for training the students' metacognitive skills.

In science processing skill, it is found that the average of science process skill (SPS) of the students taught using inquiry-based learning (IBL) is in a good category, whereas, those taught using the conventional learning, their SPS is only in an average category.

*Table 1. The normality test result of the metacognitive and science process skills*

| Data                  | Group        | Statistic | df | Sig.  | Normality |
|-----------------------|--------------|-----------|----|-------|-----------|
| Metacognitive Skill   | Experimental | 0,082     | 27 | 0,200 | Yes       |
|                       | Control      | 0,148     | 32 | 0,074 | Yes       |
| Science Process Skill | Experimental | 0,140     | 27 | 0,188 | Yes       |
|                       | Control      | 0,108     | 32 | 0,200 | Yes       |

Data from table 1 show that the metacognitive skill and the science process skill have a normal distribution. Out of these data, the significance value is more than 0.05. Therefore, further analysis is carried out to test the homogeneity of the data. The homogeneity of the data is presented in Table 2 below:

*Table 2. The homogeneity test result of the metacognitive and science process skills*

| Based on Mean         | Levene Statistic | df1 | df2 | Sig.  | Homogeneity |
|-----------------------|------------------|-----|-----|-------|-------------|
| Metacognitive Skill   | 3,115            | 1   | 57  | 0,083 | Yes         |
| Science Process Skill | 1,579            | 1   | 57  | 0,214 | Yes         |

Data from Table 2 reveal that the significance of metacognitive skill and science process skills is more significant than 0.05. This result indicates that the data have a homogenous variance. Thus the parametric test can be carried out through an independent t-test.

*Table 3. T-test result of metacognitive and science process skills*

| Data  | t     | df | Sig.  | Notes               |
|---|-------|----|-------|---------------------|
| Metacognitive Skill<br><i>Equal variances assumed</i>   | 6,985 | 57 | 0,000 | There is difference |
| Science process skill<br><i>Equal variances assumed</i> | 3,476 | 57 | 0,001 | There is difference |



Data from table 3 above show that the significance value is  $0.000 < 0.05$ , which indicates that there is a significant difference in the metacognitive skill of students who are taught using inquiry-based learning and those who are taught using conventional learning. In this table 3 as well, the significance value is  $0.001 < 0.05$ , indicating that there is a significant difference in science process skill between the students who are taught applying the inquiry-based learning and those who are taught using the conventional learning.

## 2. Discussion

In IBL, learning is implemented using the guideline or direction to assist students in conducting an investigation. Damopolii et al. (2015) state that IBL creates learners who are interested in learning through the investigation process. The implemented inquiry learning is initiated by a teacher who presents a problem within a school environment. Students formulate a problem statement that they must solve. In this problem-solving process, students' critical thinking is developed, where they need their metacognitive skills. Metacognitive skill serves to control the students' thinking process (Suwono, Susanti, & Lestari, 2017). On the other hand, when they present a problem statement, their science process skill is trained, as presenting a problem statement is a science process skill. Here, it is clear that at the beginning of the learning session, students have been trained to optimize their metacognitive and science process skills.

This is different from the students in the control class. They do not actively participate in solving the problem and formulating the problem statement. The teacher only provides an example of a problem from a natural phenomenon and provides an example of a problem statement without having them to actively participate in direct observation and formulating a problem statement.

This is clear that in conventional learning, metacognitive skill and science process skill are not well-trained; hence, conventional learning has no potential to train these two skills. This statement is also backed up by the

finding presented in Figure 2, where it is clear that there is a 15 points difference in students' ability to formulate problems statement between those in experiment and control class. In addition, Figure 1 also shows that the students' metacognitive skill gap is 7.89% in excellent category and 13.43% in the good category. Even though the average students' metacognitive skill in experiment skills only achieves a moderate category, this achievement is still better than those in the control group.

The findings in this study support the findings of the previous studies which conclude that inquiry-based learning can successfully increase students' metacognitive skill (Adnan & Bahri, 2018), as well as increase students' science process skill (Damopolii et al., 2018; Yakar & Baykara, 2014), especially for high school students as the subject of this study. Even though their result in metacognitive skill and science process skill do not achieve excellent category, the usage of inquiry-based learning still has better potential to train their metacognitive and science process skill compared to the conventional learning.

#### D. Conclusion

Based on the findings and discussion in this study it can be concluded that inquiry-based learning has the potential to train the metacognitive and science process skills of the students compared to conventional learning. Inquiry-based learning can train metacognitive skills moderately and process the skill of science well. This finding serves as a reference for senior high school teachers as their initial step in developing both skills. The development of these two skills in an effort to prepare students to be able to compete and strive in this globalization era. The limitation of this study is that the applied inquiry-based learning is yet able to increase the metacognitive and science process skills of the students to the excellent category. For this reason, future research is expected to more comprehensively study this issue with its variations to be implemented in the learning process for a better outcome.



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