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The effect of inquiry-based science learning on students' level of thinking

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Abstract. Student thinking in biology lessons has become the main focus of several recent studies. The research aims to reveal: (1) Differences in student level of thinking before and after the implementation of inquiry-based science learning; (2) Differences in student level of thinking before and after the application of conventional learning; and (3) differences in student level of thinking between students taught by inquiry-based science learning and conventional learning. Samples were 63 students in class X IPA SMA Negeri 2 Fakfak, West Papua. A total of 30 students in the experimental group, and 33 students in the control group. Data were collected using 9 items of students' thinking ability test. To measure the thinking level of students, rubric 5 levels of SOLO Taxonomy are used. Data analysis were used Wilcoxon test and Mann Whitney Test. The results of the analysis show that 29 students experienced an increase and 1 student remained at the level of thinking in inquiry-based science learning class ($p < .05$), 14 students experienced an increase and 19 students remained at the level of thinking in the conventional learning class ($p < .05$), and students who taught inquiry science learning has a better level of thinking compared to students in conventional learning ($p < .05$). We conclude that inquiry-based science learning has a better effect on the level of thinking of students than conventional learning. Going forward, to improve students' thinking skills, teachers can use inquiry-based science learning.

1. Introduction

Human need education in their long-life [1]. Science education is one part of the education they need. Interesting in science has decreased, so it is necessary to use innovative learning in science classes [2]. Nevertheless, 126 of the 348 students studied were still interested in science classes [3]. Students who have been researched state that science is their favorite lesson, they were interested and enjoy learning science. The pleasure of a subject has a positive relationship with inquiry skills so that their interest can be enhanced in scientific inquiry [4]. Students feel that they were good students if they behave well and can remember the lessons taught by their teachers in science classes [5]. Innovative movements need to be carried out so that students can gain knowledge and skills in teaching through the use of inquiry learning [6], especially in teaching biology [7]. Inquiry learning helps students who are at risk of dropping out of school [8].

Inquiry learning in science learning is useful [9]. Learning that can accommodate the nature of science is inquiry learning [10]. Inquiry learning crucial for education science [11]. The application of inquiry fosters student skills [12,13]. A principle of inquiry learning is the active role of students in learning [14]. Inquiry-based science learning was conducted in teaching and learning biology for a long time [15]. Inquiry learning in science lesson contributes to positive relationships with student performance [16], and in the biology, it was can raise the level of thinking students achieve higher order thinking skills [17–19]. It is effective for a biology lesson [20]. Inquiry-based science learning has benefits for thinking students. increasing the level of thinking of students is necessary. A student in learning requires good thinking skills. The higher the level of thinking of students, the better their understanding.

The level of thinking of students can be seen based on the structure of observed learning outcomes (SOLO) taxonomy. High order thinking students in inquiry-based learning are evaluated using SOLO Taxonomy [21]. The level of thinking of students in this taxonomy consists of five levels, the first level is pre-structural, the second is unistructural, the third is multi-structural, the fourth is relational, and the fifth is extended abstract [22–24]. It is effective for use in teaching and learning [25]. The design of a learning topic that follows the SOLO taxonomy is to describe the increasing level of student captivity [26]. Students in the inquiry-based learning class can reach the high thinking level of SOLO taxonomy, that is extended abstract [21].

Based on the study that has been described, the inquiry-based science learning is learning that matches the biology subject. Inquiry-based science learning is able to raise the level of thinking of students. The objectives that are the focus of the research are (1) Differences in student level of thinking before and after the implementation of inquiry-based science learning; (2) Differences in student level of thinking before and after the application of conventional learning; and (3) differences in student level of thinking between students taught inquiry-based science learning and conventional learning. The results of the implementation of learning in the biology class are discussed.

2. Methods

We were taking the type of quasi-experimental research. This research was using a nonequivalent control group design. The population of the research was 272 students at *SMA Negeri 2 Kabupaten Fakfak*, West Papua. The population is spread in 8 classes. 4 social science classes, 1 Language class and 3 natural science classes. A total of 2 groups of 3 natural science classes were taken using a purposive sampling technique. The total sample was 63 students. They were in class X Science 1 was 33 students and in class X science 2 was 30 students. Students in class X science 1 were taught to use conventional learning. Students in class X science 2 were using inquiry-based science learning. Thinking skill data collection was used 9 items essay test for thinking skills.

Instruments were the lesson plan, student book, student worksheet, and thinking skill test. Thinking level measurement was used rubric based on SOLO Taxonomy. It was of five levels, that is pre-structural (P), unistructural (U), multi-structural (M), relational (R) and extended abstract (EA). SOLO taxonomy was used to evaluate the answer of students [27]. Instrument research was validated by six validators. The validation results were obtained by the lesson plan was 96.05%, the student book was 88.65%, the student worksheet was 93.59%, and the thinking skill test was 93.33%. The instruments were declared appropriate for use in learning.

Data analysis consists of two, first was descriptive analysis. At this stage, the achievement of five skill thinking levels was described as the percentage of each achievement. The second was inferential analysis. This analysis consists of the first test was used the Wilcoxon test. The Wilcoxon test to test: (1) Differences in student level of thinking before and after the implementation of inquiry-based science learning; and (2) Differences in student level of thinking before and after the application of conventional learning; The second test uses the Mann Whitney test. The Mann Whitney test was used to test the differences in the pre-test and post-test of the experimental and control groups.

3. Results and discussion

The results of the present study are the differences between student level of thinking before and after the implementation of inquiry-based science learning, data on differences in student level of thinking before and after the application of conventional learning, data on differences in pre-test experimental and control groups, and data on differences in post-test experimental and control groups. The five levels of thinking discussed in the results are pre-structural (P), unistructural (U), multi-structural (M), relational (R) and extended abstract (EA).

Table 1. Wilcoxon test result.

		N	Mean Rank	Z	Sig.
Post-test – Pre-test of Experimental Group	Negative Ranks	0[a]	.00	-4.849[b]	.000
	Positive Ranks	29[b]	15.00		
	Ties	1[c]			
	Total	30			
Post-test – Pre-test of Control Group	Negative Ranks	0[d]	.00	-3.638[b]	.000
	Positive Ranks	14[e]	7.50		
	Ties	19[f]			
	Total	33			

Based on Table 1 it can be seen that both inquiry-based science learning and conventional learning have an influence on the thinking level of students ($p = .000 < .05$). Percentage of increase and decrease in the level of thinking of students in each group shown in Figure 1.

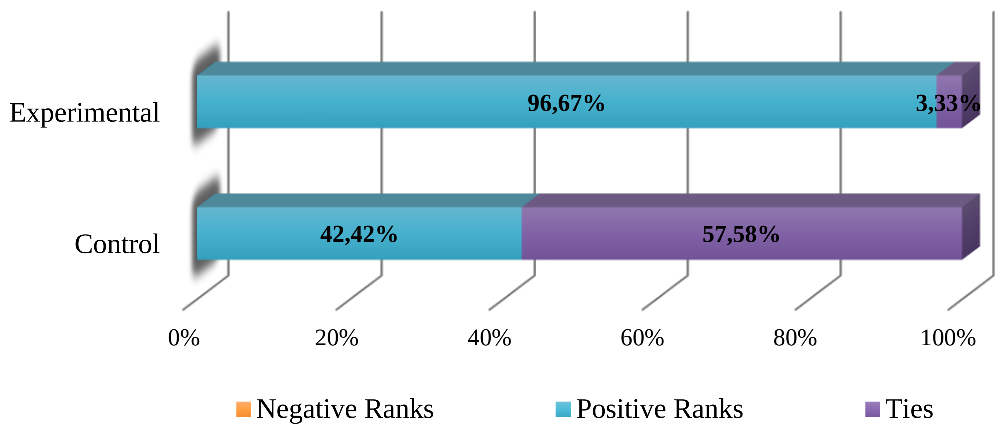

Figure 1. Graph percentage of increase and decrease in the level of thinking of students in the experimental and control group.

Figure 1 shows that there were 96.67% of students who experienced an increase in thinking in the experimental group. In the control group, there were only 42.42% of students who experienced an increase in the level of thinking, the other was ties.

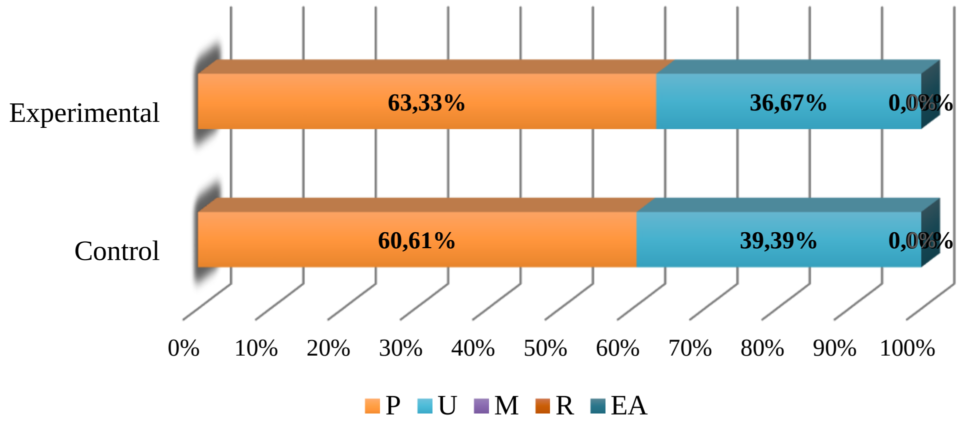

Figure 2. Graph percentage of achievement of pre-test of students' level of thinking in the experimental and control groups.

Figure 2 shows that the achievement of each level of thinking base on SOLO Taxonomy. There it was seen that both inquiry-based science learning and conventional learning were only reaching unistructural levels. There were no students who reached the level of the multi-structural, relational and extended abstract. The difference test results in Table 2 suggest that there was no difference in the level of student participation between inquiry-based students in learning and conventional learning. This proves that the level of thinking of students is the same in the initial conditions.

Table 2. Mann Whitney test result of students initial level of thinking.

Data	**Group**	**N**	**Mean Rank**	**Z**	**Sig**
Pre-test	Experimental	30	33.65	-.810	.418
	Control	33	30.50		
	Total	**63**			

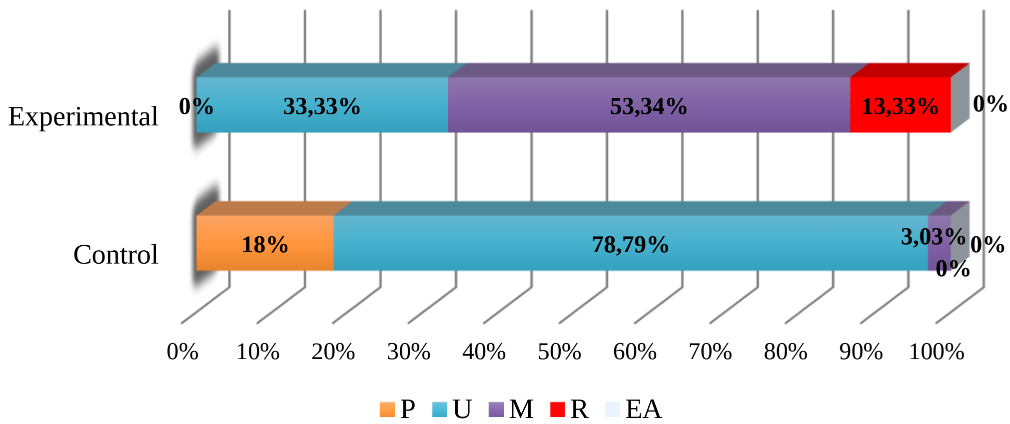

Figure 3. Graph percentage of achievement of post-test of students' level of thinking in the experimental and control group.

Figure 3 presents the different levels of thinking of students at the end of learning. It is seen that there were students who only reach pre-structural, greater at unistructural level, and at least multi-structural level in conventional learning class. While student achievement in the level of thinking in the experimental group is relational. Students in the experimental group were more attainable levels of thinking than the control group.

Table 3. Mann Whitney test results of students final level of thinking.

Data	Group	N	Mean Rank	Z	Sig
Post-test	Experimental	30	21.18	-5.015	.000
	Control	33	41.83		
	Total	**63**			

The results of the post-test analysis in Table 3 show that there were differences in the level of thinking of students in the experiment and control groups. Achievement of the level of thinking of students in the class of inquiry-based science learning is more than conventional learning. Other researchers showed that after learning, the experimental group and control did not differ significantly based on pre-structural, unistructural, multi-structural, and relational levels [27]. Different research found by the author is that students reach the relational level, but only students in the experimental group, while in the control class only achieve multi-structural levels. Overall we found there were significant differences between students who were taught inquiry-based science learning and conventional learning. Inquiry learning does not provide effective effects of progress on thinking skills [28], but we assume that when inquiry-based students in science learning are achieving a relational level and better than conventional learning, there is progress in thinking students. Table 1 shows that both learnings have an effect on increasing student thinking levels, but when compared to post-test (see Table 3), we find that inquiry-based learning is better. Students in inquiry class have good thinking compared to students in the conventional learning class [29].

Other research conducted in Indonesia shows that students can reach extended abstract levels [30]. In our study, it was found that students in the experimental group had better outcomes than students in the control class, but no students reached the extended abstract level. Students can obtain new knowledge if they make good use of their thinking skills [31]. Students have good thinking can succeed in learning [32]. In the inquiry stage, there is a process of asking questions. Learning inquiry encourages the emergence of good questions from students [15]. When students ask, their brains begin to think about how the question will be investigated. When they get data after the data collection process, they think of connecting between the data obtained with the theory. When they can explain a fact or concept by adding to link some solutions to the task, this is where they have reached the relational level. The presence of 13.33% of students reached the relational level in the inquiry-based science learning class, while in conventional learning classes no student reached this level, it is clear that inquiry-based science learning in biology lessons helped students to think higher.

4. Conclusion

Based on the results obtained, it can be concluded that the use of inquiry-based science learning has an influence on the level of thinking of students. In the class of inquiry-based science learning the level of thinking students can achieve relational, while in the conventional class of learning students only reach multistructural levels. The limitation of this research is that there is no student who reaches the extended abstract level of SOLO Taxonomy. Future research can add innovation to inquiry-based science learning classes to enhancing the level of thinking of students. In the practice of teaching biology in schools, when teachers have a goal to increase the level of thinking of their students, inquiry-based science learning is learning that can be used.

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