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The Student Ability in Graph Understanding for Mastering Natural Science Concepts through the Process Skills Approach

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The graph understanding for mastering the natural science concepts through the process skills approach aims to improve student ability in lower secondary school. In this study, we conducted a series of quasi-experiments for participants by using pre-test and post-test. The research instruments consisted of two tests and the questionnaires. After learning through the process skills approach, the post-test was used to evaluate the graph understanding and the mastery of natural science concepts. The aspects of written communication, interpretation, conclusion, and prediction were evaluated for the graph understanding while the aspects of knowledge, comprehension, application, analysis, synthesis, and evaluation were evaluated for the mastery of the concepts. The data were analyzed quantitatively by average scores and level categories. The t-test formula was used with a 5% significance level for the treatment effectiveness. The results showed that the enhancement of graph understanding can increase the concept mastery. The difficulties in understanding the graphs were closely related to the student mastery of prerequisite skills such as the basic concepts of mathematics. Then, the prerequisite skills are very important to improve their knowledge.

Keywords: concept, graph, natural science, process skills approach, student ability

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INTRODUCTION

The data presentation can be displayed in the narrative, table, and graphic forms (Duquia, Bastos, Bonamigo, González-Chica, & Martínez-Mesa, 2014). A graph is an effective, interesting and easy way to read the data compared to the others (In & Lee, 2017). The graph can be found in various sources such as newspapers, magazines, journals, and textbooks. In the natural science textbooks, there are many graphs to support the concepts (Kelly, Jasperse, & Westbrooke, 2005), such as population numbers in Asian countries, a human embryo, algae growth, ecosystems, interdependence, and the comparison of agricultural products in a region. Meanwhile, there are several activities that can make students understand a concept including visual activities (e.g. reading, observation, demonstration, experiment, construction making, and playing), mental activities (e.g. responding, remembering, problem-solving, analyzing, finding the relationship, and decision making), and drawing activities (e.g. making the graph, map, and diagram) (Diederich, 1936). From these activities, the graph understanding by performing drawing activities will inspire and motivate students in learning natural science concepts. The graph understanding can help students to organize, present, find the relationship, and evaluate the data.

In addition, the graph understanding ability can help the students to think creatively, critically, and accurately (Jackson, Edwards, & Berger, 1993). The graph understanding is the most important part of learning natural science concepts like the process skills approach (Osman & Vebrianto, 2013; Withers, 2016). Several types of graphs such as the table, bar, line, circle, and image graphs are often used in natural science textbooks (Leinhardt, Zaslavsky, & Stein, 1990; Oruc, Ugurlu, & Tokcan, 2010). Therefore, the data must be presented with suitable graphic types to make it easier to understand (Kozak, 2010). Jackson reported that the students can recognize only the line graphs (Jackson et al., 1993). The students' mastery of the basic graph concepts was still low. They cannot interpret the significance of the graphs. The drawing and interpretation of the graphs are very important for the students in learning natural science concepts because they are integral parts of the learning process. The students can predict the relationship between the variables and try to calculate their values. Furthermore, the students had difficulty in presenting circular shapes, two dimensions, and line graphs (McKenzie & Padilla, 1984; Wavering, 1989). Interestingly, 4^{th} to 6^{th} grades of elementary school students can easier understand the image and circle graphs than line graphs. Moreover, the students were difficult in finding dependent and independent variables (Leatham, 2009). In addition, the students with low ability in graph understanding cannot correctly define the graph types, so that they are difficult in drawing the graphs (Gültepe, 2016). Therefore, the graph understanding is a very important part to master the natural science concepts (Gültepe, 2016).

Graphic Functions and Its Relationship with Process Skills Approach

The graphs can generate student interests, simplify complex information, and support the concepts in the textbooks (Dickinson, 1973; Francis, 2015; In & Lee, 2017; Lohse, Walker, Biolsi, & Rueter, 1991; Onasanya, 2004; Wright, McTigue, Eslami, & Reynolds, 2014). The graph is used as one of the data presentation tools (Hawtin, 2016).

The graph with its function to summarize the information and present it generally in the figure is a superiority to effectively and clearly convey the data (Jackson et al., 1993). The graph can summarize the data presentation after obtaining the information backgrounds and other learning resources. The graph is a learning resource to reveal the meaning contained herein (Shabiralyani, Hasan, Hamad, & Iqbal, 2015). Therefore, the graph is an effective material in the learning process, especially for natural science concepts.

In addition, the graph drawing and its understanding are the parts of the process skills approach (Gultepe, 2016; Gultepe & Kilic, 2015; Harsh & Schmitt-Harsh, 2016; Irwanto, Rohaeti, Widjajanti, & Suyanta, 2017). The students can solve the daily simple problems by improving their skills in graph understanding. The aspects of process skills approach include the observation, classification, interpretation, prediction, making a hypothesis, controlling variables, planning and conducting a research, and communication (Darus & Saat, 2014; Gürses, Cuya, Güneş, & Doğar, 2014; Joseph, Cecilia, & Anthonia, 2017; Sunyono, 2018). The relationship between the graph and the process skills approach is to communicate the data with the graph from the observations. Looking for the relationship between the variables and the data tendency through the graphs requires the skills in interpretation, conclusion, and prediction. Therefore, the students are required to understand various skills to find and process the information from various sources, not only from the teachers. The process skills approach involved in graph understanding are as follows: 1) The skills of written communication (the ability to write the data, information, and the outcomes of learning activities in graphs); 2) The skills of interpretation (the ability to process and use the observation data); 3) The skills of conclusion (the ability to take a conclusion from the data processing); and 4) The skills of prediction (the ability to make a prediction based on the pattern trends of the data) (Dirawat, 1993).

Graphic Roles in Natural Science Learning

There are many graphic drawing activities that can attract students' attention such as the observation of the plant growth and the calculation of the population types of living things in surroundings. These activities must be developed so that the students can check the conditions that are critically described in the graphs. Then, they can decide the best way to collect the data and make the graph to present the data. Therefore, students are more active in thinking. The process skills approach can improve the students' mastery in drawing and understanding the graphs (Meisadewi, Anggraeni, & Supriatno, 2017). The graph understanding is the ability to translate something in its own words, explain an idea expressed in a way other than the original statement, and interpret, conclude, and predict the graphs. The graphs are often found in some natural science concepts such as the population in lower secondary school. The sub-concepts of ecosystems and interdependence are the units of living things in ecosystems; biotic and abiotic components; autotrophic organisms; heterotrophic organisms; biotic and abiotic influence each other; and interdependence between producers, consumers, and decomposers. The examples of the graphs presented in the concepts of ecosystems and interdependence are including the world population growth, changes in the number of plant populations, comparison between growth of onion leaves and roots, conversion of light energy into chemical energy and chemical energy into work energy, the relationship of interdependence between biotic and abiotic environments, ecological pyramids, and natural balance.

Aims of the Study

The aims of this study are to evaluate the lower secondary school’s student ability in understanding the graphs and the correlation with the natural science concept mastery. We evaluated the aspects of written communication, interpretation, conclusion and prediction in understanding the graphs and the concept mastery of cognitive domains. This study specifically aimed 1) to examine the learning outcomes in the aspects of written communication, interpretation, conclusion, and prediction and in the aspects of cognitive domains; 2) to examine the students' difficulties in understanding the graphs; and 3) to obtain the student and teacher responses about the learning by using a process skills approach to understand the natural science concepts.

METHOD

Research Design

The data were obtained from a series of quasi-experiments. One class from eight classes was selected purposely as an experiment class. Before treatment, a pre-test was given to the students in the experiment class. Then, the treatment was carried out by teaching with a process skills approach. This research was limited to ecosystems and interdependence concepts with six sub-concepts. The sub-concepts of ecosystems are units of living things in the ecosystems, ecosystem components, autotrophic organisms, and heterotrophic organisms. The sub-concepts of interdependence are biotic and abiotic components influence each other and interdependence between producers, consumers, and decomposers. After learning, the post-test was given to evaluate the graph understanding and concept mastery.

Participants

This research was conducted in Bandung state lower secondary school. The population was all students in 8^{th} grade. The participants were the students from a selected class determined purposely by the vice-principal of the curriculum affairs. The participants were 43 students with 23 boys and 20 girls. There were two natural science teachers who taught in the 8^{th} grade at this school. Only one teacher taught natural science in the treatment class with three hours of teaching time per week.

Research Instruments

Two research instruments were used for processing and analyzing the data. They were two tests and the questionnaires. In detail, the research instruments are as follows: 1) The test for graph understanding consisted of 26 test items with 10 items for the graph drawing aspect (table, bar, line, circle, and image graphs), 9 items for the interpretation aspect, 4 items for the conclusion aspect, and 3 items for the prediction aspect; 2) The test for concept mastery consisted of 24 test items on the aspect of cognitive domains with 3 items for knowledge aspect, 9 items for comprehension aspect, 3 items for application aspect, 4 items for analysis aspect, 2 items for synthesis aspect, and 3 items for application aspect; 3) A questionnaire was used to obtain the information about the student difficulties in understanding the graphs; 4) A questionnaire was used to obtain the students and teacher's responses for the learning program with the process skills approach.

The measuring tools must meet the validity and reliability requirements. All research instruments were developed specifically to learn the ecosystems and interdependence concepts. To obtain the validity, the test items were arranged based on the concepts and the tested abilities. In addition, the test items and their answers have been carefully corrected with the natural science teacher. Therefore, the test has content validity. The internal validity of test items from trial data was also tested. From the test item analysis, it can be determined the value of correlation (r) between each test item with the total score (Bewick, Cheek, & Ball, 2003). Cronbach's alpha formula was used to meet the validity and reliability requirements because the research instruments were in the description form (Taber, 2017; Tavakol & Dennick, 2011). The other instrument criteria are explained in trial test analysis techniques.

Trial Test Analysis Techniques

The resulted data were analyzed for the difficulty index, discrimination power, validity, and reliability. The score determination was based on the suitability of the student answers with the test answers. In this case, the students' answers are true if 75% of their answers are fit with the test answers. The difficulty index and discrimination power were determined by using P and D formula, respectively (Suruchi & Rana, 2014). The analysis of the difficulty index was done to avoid the subjectivity in estimating the difficulty level of the test items. The difficulty index was expressed as the percentage of the number of students with the correct answers to the total number of students. While the discrimination power shows the level of test item ability to distinguish low and high achievement groups among the students (Suruchi & Rana, 2014). The validity was done to obtain the test items with reliable validity by using r formula (Bolarinwa, 2015). Reliability was tracked by using the Alpha reliability coefficient. The reliability refers to the consistency of the measurement results (Gaberson, 1997). The interpretation of r values and the reliability degree can be seen in Table 1. Based on the calculation, the reliability degree for the graph understanding test was at a high level with $r = 0.746$. While the reliability degree for the concept mastery test was at a moderate level with $r = 0.500$. Therefore, both two tests can be used.

Table 1
The Interpretation of r Values and the Reliability Degree Criteria

r values	Interpretation	r values	Reliability degree
0.80 – 1.00	Very high	$0.80 < r \leq 1.00$	Very high
0.60 – 0.79	High	$0.60 < r \leq 0.80$	High
0.40 – 0.59	Middle	$0.40 < r \leq 0.60$	Middle
0.20 – 0.39	Low	$0.20 < r \leq 0.40$	Low
0.00 – 0.19	Very low	$r \leq 0.20$	Very low

Techniques for Research Data Analysis

The data from the test scores were categorized into 4 levels. They are very good (1), good (2), moderate (3) and low (4) levels (Table 2). The highest score was 5 and the lowest score was below 2.75. The data were analysed with the following steps. First, the data was obtained through the pre-test results to find out the initial graph understanding and concept mastery. The data were quantitatively analysed by using average scores and level categories for each aspect. Second, the data was obtained by using the post-test results to find out the learning outcomes after treatment with the process skills approach. The data were analyzed by mean values. Third, the data were analysed by comparing the scores of pre-test and post-test to find out the enhancement of the concept mastery after treatment. Forth, the data from the test results were first tested their normality to examine the significance of learning outcomes. Then, the t-test was used to check the effectiveness of the treatment.

Table 2
Graph Understanding and Concept Mastery Categories

Category	Percentage (%)	Achievement score	Annotation
Very good	80 - 100	4.00 – 5.00	VG (1)
Good	66 - 79	3.30 – 3.95	G (2)
Moderate	56 - 65	2.80 – 3.25	M (3)
Low	< 55	< 2.75	L (4)

FINDINGS

Student Understanding of the Graphs

The data of graph understanding obtained through a pre-test and a post-test include the aspect of written communication (graphic drawing), interpretation, conclusion, and prediction. Table 3 shows the student mastery in drawing the graphs before and after learning. The average percentage of the score was 48% and 70% for the initial and final, respectively. Furthermore, the initial mastery in drawing the graphs ranged from 34% to 73%. The final mastery in drawing the graphs ranged from 48% to 91%. The initial student mastery was still in level 4 and after learning was in level 2. After learning, the mastery enhancement in drawing the graphs was ranging from 14% to 37% with a 22% average (Figure 1). The lowest enhancement was for the line graph (14%) and the highest enhancement was for the circle graph (37%).

Table 3
The Student Mastery in Drawing the Graphs of the Ecosystems and Interdependence Concepts (μ_1 = initial average, μ_2 = final average).

Graph Types	μ_1	%	μ_2	%	μ_2-μ_1
Table	7.27	73	9.09	91	1.82
Bar	9.07	45	15.0	75	5.29
Line	3.39	34	4.76	48	1.37
Circle	2.25	45	4.09	82	1.84
Image	2.02	40	2.84	56	0.82
Average	4.80	48	7.17	70	2.37

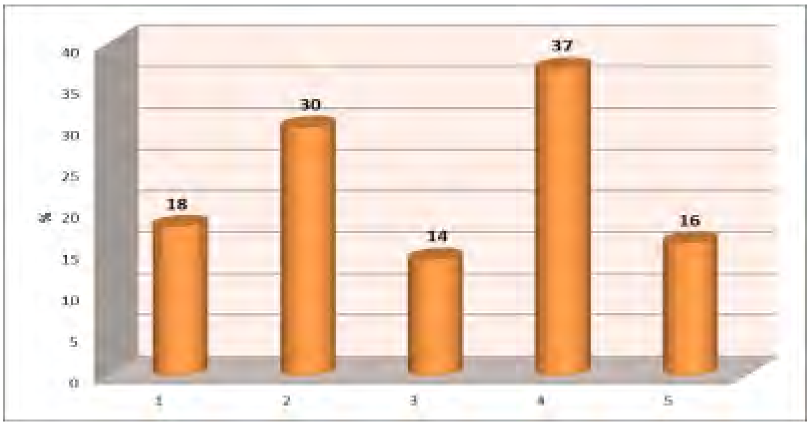

Figure 1
The Enhancement Percentages in Graph Drawing Mastery of Various Graphs (1 = table, 2 = bar, 3 = line, 4 = circle, 5 = image)

Furthermore, the student mastery in understanding the graphs before and after learning is summarized in Table 4 and Figure 2. The average score of the initial mastery of graph understanding was 42%. The average score of each aspect of graph understanding was 48% for graphic drawing, 40% for interpretation, 41% for conclusion, and 30% for prediction. The initial student mastery in understanding the graphs was in level 4. After learning, the average score of student mastery in understanding the graphs was 61%. The average score was in level 2 for graphic drawing, level 3 for interpretation and conclusion, and level 4 for prediction. The student mastery in understanding the graphs was generally categorized in level 2 and 3 except for the prediction aspect. Although the prediction aspect was in level 4, there was a little enhancement of the score after learning.

Table 4
The Student Mastery in Understanding the Graphs of the Ecosystems and Interdependence Concepts

Initial mastery for graph understanding aspects					
	D	I	C	P	μ_1
μ_2	24.02	18.38	8.16	4.58	55.15
s	6.12	4.97	2.75	1.56	12.56
%	48	40	41	30	42
Final mastery for graph understanding aspects					
	D	I	C	P	μ_1
μ_2	34.91	26.76	11.23	6.33	79.22
s	6.09	5.83	3.57	2.31	15.58
%	70	59	56	42	61

(μ_1 = the average of overall mastery, μ_2 = the average of each mastery aspect, D = drawing the graphs, I = interpretation, C= conclusion, P = prediction)

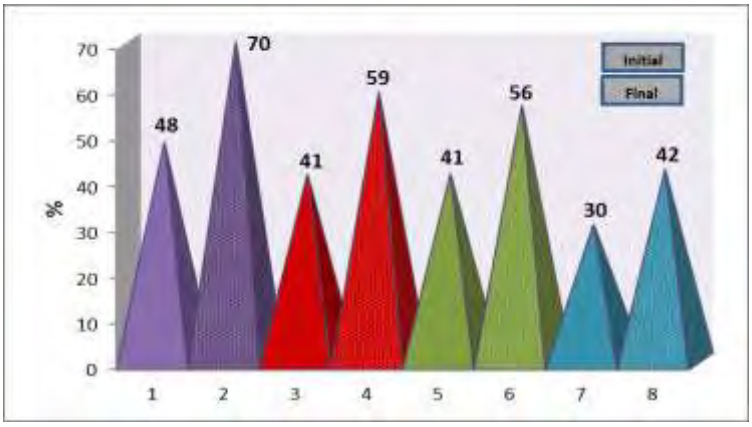

Figure 2
The Percentage Mastery of Graph Understanding for Each Aspect (1-2 = D, 3-4 = I, 5-6 = C, 7-8 = P)

The Mastery of Ecosystems and Interdependence Concept

The student mastery of ecosystems and the interdependence concept was evaluated through 24 test items. The aspects of concept mastery include knowledge, comprehension, application, analysis, synthesis, and evaluation. The mastery of the concepts before and after learning from six aspects of cognitive domains was shown in Table 5. The average score for initial concept mastery was 24% (level 4). After learning, the average score of concept mastery was 60%. The highest average score (72%) and the lowest average score (49%) were for the application and evaluation aspects, respectively. The average mastery for knowledge and application aspects was in level 2. While, the average mastery for the comprehension, analysis, and synthesis aspects was in level 3. Only the aspect of the evaluation was still in level 4. Then, the concept mastery was generally in level 3.

Table 5
The Initial and Final Concept Mastery of the Ecosystems and Interdependence

Initial mastery for cognitive domain aspects							
	C1	C2	C3	C4	C5	C6	μ_1
μ_2	4.34	11.33	6.26	5.45	2.45	4.21	28.36
s	2.85	6.52	3.07	2.84	1.18	1.95	15.15
%	29	25	42	27	25	28	24
Final mastery for cognitive domain aspects							
	C1	C2	C3	C4	C5	C6	μ_1
μ_2	9.92	25.58	10.86	12.21	6.19	7.42	72.13
s	3.08	6.72	2.49	3.33	2.92	3.08	16.65
%	66	57	72	61	62	49	60

(μ_1 = average concept mastery for all aspect, μ_2 = average concept mastery for each aspect, C1 = knowledge, C2 = comprehension, C3 = application, C4 = analysis, C5 = synthesis, C6 = evaluation).

The Correlation between Graph Understanding and Concept Mastery

The correlation between the graph understanding and concept mastery before and after learning was shown in Table 6. Before learning, 91% of students were in level 4 for the graph understanding and concept mastery. There were 2% of students in level 4 for graph understanding and level 3 for concept mastery. 7% of students achieved levels 3 and 4 for the graph understanding and concept mastery, respectively. The results showed that many students achieved level 4 for both graph understanding and concept mastery. After learning, the graph understanding and concept mastery were in level 1 (7%), level 2 (23%), level 3 (14%), and level 4 (19%). It was found that 2% of students who understood the graphs in level 1 and mastered the concepts in level 2. 9% of students achieved level 3 for the graph understanding and level 2 for the concept mastery. Conversely, 12% of students were in level 4 for graph understanding and level 3 for the concept mastery. Most of the students achieved level 2 for graph understanding and concept mastery.

Table 6
The Correlations between the Test Results of Graph Understanding and the Concept Mastery after Learning

Level of graph understanding	Level of concept mastery before learning				
	L (4)	M (3)	G (2)	VG (1)	Total
L (4)	91%	2%	0%	0%	93%
M (3)	7%	0%	0%	0%	7%
G (2)	0%	0%	0%	0%	0%
VG (1)	0%	0%	0%	0%	0%
Total	98%	2%	0%	0%	100%
Level of graph understanding	Level of concept mastery after learning				
	L (4)	M (3)	G (2)	VG (1)	Total
L (4)	19%	12%	0%	0%	31%
M (3)	12%	14%	9%	0%	34%
G (2)	2%	0%	23%	0%	26%
VG (1)	0%	0%	2%	7%	9%
Total	33%	26%	34%	7%	100%

Students' and Teacher' Responses for the Learning Activity

The questionnaire was given after learning to find out the student's responses about learning activity and their difficulties in understanding the graphs. The student answers for each questionnaire item were presented in percentage of the given answers. There were 67% of students who were happy with the learning activity if there is a practicum activity, and 19% of students who are very happy because it is not boring. 49% and 39% of students will ask their classmates and teacher, respectively, if they get difficulty in learning. There are 56% of students got the knowledge about the graphs in elementary school, 35% of students obtained it in learning natural science, 7% of students obtained it in learning mathematics, and 2% of students who never got the knowledge. 72% of students can give the meaning of the graph based on the data if they find the graphs in newspapers, magazines, or books. In addition, 98% of students can differentiate graphic types. From all of the graphic types, most of the students (33%) were difficult to understand the circle graph. There were 46% of students who have difficulty in determining independent and dependent variables, determining the scale, giving information, and connecting the point pair. 51% of students knew the drawing steps of the line graph, 56% of students knew the drawing steps of a circle graph, and 42% of students knew the drawing steps of image and bar graphs.

Another questionnaire for the teacher's responses was also given after learning. The response aimed to get a description of the student condition in the learning activity. The teacher gave positive responses to the learning activity through the process skills approach. The student assignments were always collected and corrected by giving the feedbacks and then returned to the students. So, the teacher was very concerned about the student work results. In addition, the teacher suggested that the students needed to master various knowledge especially those related to basic concepts of mathematics. The approaches, methods, and appropriate ways to deliver certain materials in class are very important. The concepts are better to be presented in the graphs both in class and practical activities. From these responses, the concept mastery can be related to the graph understanding. The teacher believed that the improvement of graph understanding in natural science learning is very good to be applied. The graph understanding can help the student to master the concept of natural science. From this opinion, it can be stated that the graphs are very useful in learning natural science.

DISCUSSION

The Mastery of Graph Understanding

The implementation of the process skills approach is more effective to help the students in understanding the relationship between natural phenomena and the graph representation (Jackson et al., 1993). A topic presentation with a graph can help the student to organize, present, evaluate, and design the experiment in solving the learning problems. The mastery aspects in graph understanding include graphic drawing, interpretation, conclusion, and prediction. For the graphic drawing, the initial student mastery was still in level 4. The students were not challenged to think critically and analytically about a concept. Therefore, critical and analytical thinking is demanded in learning natural science (Munns & Chilton, 2014; Puspita, Kaniawati, & Suwarma, 2017). After learning, the final mastery in graphic drawing was enhanced to level 2. 33% of students argued that the circle graph was the most difficult graph to understand because the students did not make any explanations on the percentage part. Furthermore, the low increase of achievement in the line graph (14%) compared to other graph types was due to 21% of students who did not master the prerequisite knowledge especially to the drawing steps of the line graph. The steps to draw a correct graph are the process skills that students must master them (Quillin & Thomas, 2015). The abstract concepts of the ecosystems and interdependence are another reason. For example, the students were given an observation worksheet about the surrounding environment. After observation, the students made the written reports such as the line graph for the concept of interdependence of living things with the abiotic environment.

In the interpretation aspect, the initial mastery was still in level 4 whereas the final mastery was in level 3. The results showed that the process skills approach can enhance the graph understanding. The students must be able to interpret the condition based on the data contained in line and bar graphs. From the student answers of the questionnaire, 51% of students knew the prerequisite knowledge about the drawing steps of the line graph and 42% of students knew the prerequisite knowledge about the drawing steps of the bar graph. The students can easily find the relationship among the variables in the graphs with the concepts if the students know the drawing steps of graphs. The mastery in the interpretation aspect is better if the students have the knowledge of graphic drawing steps than that of the students without or less of the knowledge. For the conclusion aspect, the initial mastery of graph understanding was in level 4 and the final mastery was in level 3. The mastery of the conclusion aspect is the ability of a student to take a conclusion from the collected data. The conclusion from the observation result data uses inductive logic (Sprenger, 2009). The student difficulties in the conclusion part were about determining the independent and dependent variables, determining the scale, giving information, and connecting the point pair.

Furthermore, for the prediction aspect, the average score of initial mastery was in level 4 and the final mastery was still in level 4 with a little increment. In other words, the students cannot predict the tendency of the graphs that occurs based on the known data. The mastery in the prediction aspect is the ability in predicting the tendency based on the obtained data or outside the data. The prediction is based on the understanding of the tendencies or conditions described in a communication (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). Then, the prerequisite skills are required to master the prediction aspect. The students involve a higher and challenging thinking process by using the knowledge that recorded in their memory in prediction activity (Bloom et al., 1956). The lack of student mastery in the prediction aspect was because the students were requested to determine the changes of living things' population in ecosystems through the graphs and predict the possibility of the human population in the future. In this case, the students cannot correlate the concrete situations with their everyday life. In addition, it was also caused by the lacking of prerequisite basic concepts of mathematics. This lack can be seen from the evaluation of the questionnaire answers in which only a few students obtained the knowledge about the graphs when learning natural science, in elementary school, and learning mathematics. Gredler stated that prerequisite skills must be remembered to make smooth learning without any difficulties. Therefore, the prerequisite skills are important in developing the teaching model through the graph presentation (Gredler, 2009).

The Concept Mastery on the Cognitive Domains

The mastery of the concepts was evaluated through six aspects of cognitive domains. The average concept mastery on the cognitive domains was in level 4 before learning and in level 3 after learning. The initial concept mastery for each aspect was still in level 4. After learning, the knowledge and application aspects were in level 2; the comprehension, analysis, and synthesis aspects were in level 3; and the evaluation aspect was still in level 4. The students were required to be more active in the learning process. The students were given an observation worksheet to observe non-living objects and living things in the surroundings during the learning process. So, the students can associate the concepts with the concrete situations of their observation experiences. The average score in the knowledge aspect was increased from level 4 to level 2 after learning. In a test question, the students were expected to be able to explain photosynthesis products. The students must remember that photosynthesis products are O_2 gas and carbohydrates. Before learning, most of the students were in level 4 for this test because the students did not remember the photosynthesis process. The ability to remember an event occurred in our lives can store information in long-term memory (Cowan, 2008). The student can remember in a long time if the teacher can modify the learning situations with any activities (Sumarno, 1987).

Furthermore, comprehension is the ability to translate, interpret, predict, explain, and make a summary from the data (Nayef, Yaacob, & Ismail, 2013). Bloom stated that comprehension is the ability to translate something in their own words expressed in other ways from the original statement (Bloom et al., 1956). The average score of initial concept mastery in the comprehension aspect was in level 4 while the final concept mastery was in level 3. In the initial, the students were in level 4 because they could not describe a set of logical statement and they could not reduce the doubtful thing. However, the concept mastery in the comprehension aspect has a significant enhancement after learning. Then, in the application aspect, the average score of initial concept mastery was in level 4, while the final concept mastery was increased to level 2. The students can apply the previous concepts to the next concepts. Bransford stated that the principle of application aspect is the ability to apply knowledge to new situations (Bransford & Schwartz, 1999). If the students do not know the basic knowledge, then they cannot apply the knowledge to learn the higher concepts.

For the analysis aspect, the average score of initial concept mastery was in level 4 and enhanced to level 3 after learning. Many students can master the concept in the analysis aspect because they can analyze the concepts obtained from practical activities or school environment observation. From the questionnaire, 67% of students said that they were happy if there is a practical activity in the learning. The learning with practical activity can indirectly motivate the students. The motivation is a successful learning predictor (Bransford & Schwartz, 1999). Next, in the synthesis aspect, the average score of the initial concept mastery was in level 4 and was reached level 3 after learning with a significant enhancement. The teacher should create a situation in the learning process to make students not bored. Moreover, for the evaluation aspect, the average score of initial concept mastery in level 4. Although the achievement was still in level 4 after learning, the average score was slightly increased. The low increase of the concept mastery in the evaluation aspect was due to the student's ability to make the criteria, give the considerations, estimate the mistakes and accuracies, and enable to evaluate the data. The students were required to think higher to master the concepts. Another reason, the students had less interaction with their surroundings. So, the student cannot give consideration or evaluation for something that happens in the surroundings. Some students would ask their friends if they found the problems in learning the concepts. Therefore, it is expected to provide more training with concrete examples correlated to the evaluation aspect in conveying a concept with a higher mastery level.

The Correlations between Graph Understanding and Concept Mastery

Most students achieved the graph understanding and concept mastery with level 4 before learning. This finding showed that the students who achieved the graph understanding in level 4 would also achieve the concept mastery in level 4. Only a few students achieved the graph understanding in level 4 with the concept mastery in level 3. Conversely, the graph understanding was in level 3 and the concept mastery was in level 4. After learning, several students achieved level 2 for both the graph understanding and concept mastery. This finding showed that good graph understanding can result in good concept mastery. The concept mastery can be optimal if the students can master and apply the prerequisite skills to learn the concepts (Khalil & Elkhider, 2016). In addition, the students made the study group to learn the concepts and they did the school assignments enthusiastically. It was also stated that few students achieved the graph understanding in level 2 and the concept mastery in level 4 or achieved the graph understanding in level 4 and the concept mastery in level 3. This situation happened because the students had the difficulty in drawing the graph types, especially for the line graph. Thus, the lack of graph understanding also varied greatly in all aspects regarding the line graph. To avoid the student difficulties in line graph understanding, the easy way to understand terms are used in the line graph such as horizontal, vertical, maximum, and minimum that can be directly seen in the graph. For example, the students cannot answer the question about the chicken population in an area equal to x/km^2. The test was designed in a formula and the students were requested to be able to explain in a narration. However, the students cannot answer the test item in the form of formula about the chicken population. Therefore, the graph understanding is a prerequisite skill that must be mastered by the students to learn natural science concepts.

CONCLUSION

The process skills approach enhanced student skills in understanding the graphs from level 4 to level 3. This approach also enhanced the concept mastery from level 4 to level 2. Successively, each aspect of the graph understanding enhanced the achievement from level 4 to level 2 for the written communication aspect, to level 3 for the interpretation and conclusion aspects, and to the same level for the prediction aspect. The concept mastery for cognitive domains was achieved from level 4 to level 2 for the knowledge and application aspects, to level 3 for the comprehension, analysis, and synthesis aspects, and to the same level for the evaluation aspect. The difficulties in graph understanding were closely related to prerequisite skills such as the basic concepts of mathematics. Therefore, the students were less skilled in understanding the graphs of natural science concepts. The students and teacher responded very pleasantly for the learning activity by using the process skills approach to understand the graphs and to master the concepts. The process skills approach can improve the learning activity and outcomes of natural science concepts.

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