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Improving Students' Graphing Skills through Quantitative-Based Lab Activities

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Abstract. The background of this study is students have difficulties about using scientific language in graphing skills. The purpose of this study was to investigate the improving a students' graphing skills of using quantitative-based lab activities in environmental change material. A weak experimental with pre-test post-test group designs was utilized in this study. The sample consisted of 34 students of the 10th grader students in Cirebon, West Java. Instruments graphing skills test that used of this study consisted graph construction and graphs interpretation skill. Data analysis N-gain average of graphing skills of the students is 0, 66. The results of this study suggest that an increase students' graphing skills through quantitative-based lab activities in environmental change material.

1. Introduction

An anecdote suggests that students who perceive themselves as math-weak will be gravitated toward biology, since they consider biology as a subject that relatively math-free [1]. As we know, in learning activity, biology focused on domain of content and recitation, with less demand of quantitative skills. Even though, it is recognized that to support the new biology challenges in 21st century, highly developed quantitative skills is also important [2]. Based on characteristic of biology learning, it is argued that biology of the twenty-first century is an increasingly quantitative science, which will use a lot of quantitative data [3]. Association of America Colleges and Universities (AAC&U) describe six major aspects of quantitative literacy: interpretation, representation, assumptions, analysis/synthesis, and communication [4]. Data representation and interpretation are the first items of these six basic aspects of quantitative literacy. Mathematical Association of America (MAA) claims that one of the skills that help the students with quantitative skills is understanding graph.

The research focused on improving students' graph representation and interpretation or known as graphing skills. Since both of the skills are basic aspects of quantitative literacy, therefore students should understand them more deeply. Understanding graphs (graph interpretation) is a fundamental skill that plays an important role for all students in their everyday lives, where it is necessary for them to make sense and to communicate with the information presented in graphs; these are all used in media such as newspapers and television [5,6]. In addition, bar and line graph, particularly, are started easy to be found in textbook and observation result in biology class [7].

The importance of this competence is shown through placing graphing skills in many science curricula [8, 9]. Some developed countries such as Germany and California have to equip students with the knowledge graph and practice ability to construction and interpretation graph, which is realized

through the integration into school curricula [10]. Indonesia curriculum of 2013 includes these skills to be taught to students; it becomes a goal of competence standard of general education in biology. In summary, to use and to understand the graphs occupy important roles in daily life, either in science or schools. By using the graph, a lot of data explanation can be summarized. Besides, it is useful to communicate with quantitative information, so that the graphs can be more quickly and easily interpret [11]. Graph can also be used to present the experiment result, to draw conclusion and to evaluate investigation [12]. The limited emphasis teach graphing skills into the science curricula and lack of mastery of skills contributes to low students' graphing skills.

Constructing and interpreting graph are skills not easily acquired by most students. Several studies indicate that middle, high, and university students have problems with construction and interpretation graph in science class. Almost all of biology university students in each generation have problem with drawing line-graph for discontinuous data [13]. The problems of students in the aforementioned level of education are choosing correct scale, unit, and writing title of information [12]. Students have difficulty in scaling axes and connecting the dots points correctly [9]. The difficulties are particularly in providing axis labels, making the scale or the distance on the right axis, and connecting the dots correctly [14]. Students at all age levels have difficulty with interpretation graph. Some students cannot see the relationship between independent and dependent variables and how these two variables should be plotted on the axis, should build interpolation, determine x and y coordinates and plot the data, and therefore they are not able to build the right chart, label and scale axis[15].

Biology basically has great potential to practice students' graphing skills, because in biology conduct many lab activities that produced the data. But there are lab activities that produce more qualitative data, so the portion to practice graphing skills is very limited. This condition makes low achiever of the students' graphing skills because the learning is not maximized in the development of students' graphing skills. In order to improve the ability, it can be facilitated through activity that can provide direct experience for students to work with data quantitative. One potential way is through lab activities.

Lab activities are an essential activity and an integral part of learning science, including biology [16]. Teaching a graph should be taught to be started by collecting real data, it can be through hands-on activities in science learning, then students organize the acquired data, and construct a graph based on the data and interpret them [17]. Therefore, this study aimed to analyze how the achievement of capabilities graphing skills in the 10th grade students through quantitative-based lab activities on environmental changes material.

2. Method and Data Source

This study used quantitative approach to explore how students graphing skills, which consists of the abilities to construct and interpret graph. A weak-experimental with pre-test – post-test group design was used in this study. The sample consisted of 34 students of the 10th grader science students, 2nd semester in the academic year 2015/2016 .The research group was given a pre-test and then, treatment through the quantitative-based lab activities at last, the research group was given a post-test. The results of the pre-test and post-test were compared.

The graphing skills test in this study was developed by research. The graphing skills test consisted of 15 problems where they present problems related to construction and interpretation graphs; 13 problems of students to interpret graph in form of multiple choice questions which was developed based on the Bertin's theory of interpretation level, which consists of interpretation level basic, intermediate, and overall [18]. Two problems for students are related to construct graphs in the form of essay questions. The test used in study has been validated by expert lecturers and conducted trials to students with reliability of 0,52 for construction graph test and 0,58 for interpretation graph test. The test was administered to research group as a pre-test and post-test.

3. Result And Discussion

3.1. Result of Improvement of students' graphing skills

The ratio of average score of pre-test, post-test and N-Gain student's graphing skills which are obtained in the research are presented in Table 1:

Table 1. Average of pre-test, post-test and gain normalized student's graphing skills

Graphing Skills	Pre-test		Post-test		N-gain	
	Average	(%)	Average	(%)	N-gain <g>	Category
	37,38	54	58,09	84	0,66	Medium

In the Table 1, show that difference between the means scores of pre-test and post-test, with N-gain is a 0,66 point. Therefore, it was concluded that students graphing skills improving after implementation of activities. The result of significant difference was observed between pre-test and post-test using the Wilcoxon test is sig.(2-tailed) 0,000 < 0,05 (significance level). Accordingly, that is a significant difference between students' graphing skills before and after implementation quantitative-based lab activities.

The ratio of average score of pre-tests, post-test and N-gain student's construction and interpretation graph is presented in Table 2:

Table 2. Average of pre-test, post-test, and N-gain student's construction and Interpretation graph

Graphing skills	Pre-test		Post-test		N-gain	
	Average	%	Average	%	N-gain <g>	Category
Construction	29,4	52	47,35	85	0,67	Medium
Interpretation	8,00	62	10,74	83	0,57	Medium

Based on Table 2, it can be seen that both the skills of graphing is increasing after quantitative-based lab activities. The average results of graphing skills pre-test shows better performance in the interpretation of the graph, while the average post-test performance graph construction skills better than the performance of interpretation skills.

3.2. Discussion

The students' graphing skills before quantitative-based lab activities is different from after being given quantitative-based lab activities. The low pre-test results can be caused by insufficient prior knowledge to related graphing skills, as well as laziness and lack of motivation of some students in doing the task-related to numbers. The improved graphing skills could be stimulated by the lab activities provided during the four meetings, which is providing the students with real experience and to familiarize the students with working on quantitative data.

Teaching the graph should be started by collecting real data though hands-on activities in science learning. After that, the students could organize the data, construct a graph and make interpretation out of it. [17]. Students who have greater opportunities to practice constructing and interpreting the graphs, shows better knowledge and understanding in graphing skills [15]. In teaching graphing skills, the data should be obtained from the activity of student experiments, and students make their own graph manually and do not use computers [19]. Basically, after doing lab activity, the students can continue inputting the data observed in the recorded data and converts it into form of charts, graphs or images on the part of transformation [20].

Other aspects that contribute to the improvement of students' graphing skills are material content and graphics which are used during the learning process and in lab activities; by using things that existed surrounding the students, the graphs presented and selected on the circumstances of daily life can improve student graphing skills [21]. The increasing graphing skills result also shows that students have no trouble in doing lab-activities.

Pre-test results showed better performance in the interpretation. That is because the interpretation of the graph is often considered easier than creating graphics that require more than interpretation competence [5]. The fact that the interpretation is easier than making the graphs is caused by cognitive demands required to construction graph are much higher than those involved in the interpretation while making graph involves complex cognitive processes. It indicates that students can interpret information from graph but they have problems to construction a new graph [15].

Post-test results showed the contrary, the performance seen in the interpretation skill is lower than construction graph. It occurred since there is absorption of skills in construction graphs obtained by the students, particularly, it can be seen in the indicator to make title of the graphic and determine the independent and dependent variables. Improvement in the indicators led to the acquisition of construction graph skill is more apparent than making interpretation. Other factors which can influence the indicators are internal and external condition of the students, such as motivation, prior knowledge of students, health, and the students' ability of socializing in a learning environment at the time working on post-test, as well as the learning atmosphere of students who potentially disrupt students' concentration.

Making the students to master the real graphing skills is a process that requires hard work and time; it cannot be done instantly [22]. Mastery in graphing skills acquired from time to time. In addition, another important thing to improve the skill is intensive training [23]. Lab activity is basically intended to familiarize the students with graphing skills ability.

4. Conclusion

The study concludes that significant increase of students' graphing skill can be obtained through quantitative-based lab activities. Both the performance of two graphing skills; constructing and interpreting graphs are increasing. This study suggests the future research to do long-term research related to students' graphing skill and apply it to greater subject, so that research can better reflect the improvement occurred.

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