Students' Biological-Mathematical Attitude in Quantitative Literacy-Based Learning on the Topic of Ecosystem

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Abstract. This study aims to obtain information and to analyze the students' interest in using math to understand biology, the perceived usefulness of math, and the cost of using math in biology learning in quantitative literacy-based ecosystem instruction. The research used a quasi-experimental design with 131 six grade students in two high schools. The biological-mathematical attitude was obtained with the Math-Biology Values Instrument (MBVI) questionnaire and the quantitative literacy was assessed using multiple-choice questions. The results show that the majority of students feel interested, feel the benefits, and feel the importance of mathematical abilities in solving biological problems, and almost all students do not experience difficulties with mathematics in ecosystems instruction. Quantitative literacy-based learning helps the student to have a very high level of interpretation and calculation, and also a high level of representation and analysis.

Keywords: MBVI, Biological-mathematical attitude, Quantitative literacy, Ecosystem

1 Introduction

Quantitative literacy is the ability to apply mathematics to a specific context of a particular discipline. If students can link concepts with quantitative evidence, students' understanding of the concepts can be improved [1]. One of the challenges of integrating mathematics into biology is the students' negative attitude towards mathematics, which is considered very common among students towards biology subjects [2, 3]. However, the expectancy-value theory shows that students' attitudes toward assignments are an important predictor of achievement [4]. According to the research by Andrews, Runyon, & Aikens [2], students' personal values regarding the use of mathematics in biological contexts affect their achievement and behavior. These values consist of three different aspects, namely 1) aspects of interest, 2) aspects of utility, and 3) difficulties experienced. According to the Expectancy-value theory regarding the achievement motivation, students' performance (for example, an achievement on quantitative tasks) depends on how well they complete the task and expect the score of the work done. Students who believe that they can do the task well, are motivated to endure and complete the task. Thus, understanding students' attitudes towards mathematics in the biological context is an important step in the process of developing effective quantitative reforms. Math-Biology Values Instrument (MBVI) was developed To determine this attitude empirically by Andrews et al [2]. This instrument has been validated to be used as a measurement of students' personal values

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towards the use of mathematics in a biological context. Currently, there is no alternative instrument to measure students' biological-mathematical attitudes other than MBVI.

Luttrell, et al. have developed and validated MBVI which is then modeled Math-Biology Values Instrument (MBVI) as a scoring measurement of students' mathematics assignments. In previous studies, the instrument has been used to measure students' attitudes towards mathematics in biology which includes four values, including the interests, the benefits, the achievement, and difficulties experienced [5]. Reference [2] believes that MBVI can be used by teachers and researchers to help identify learning strategies that affect the scores of mathematical-biological assignments and to help understand how the scores of mathematical-biological assignments relate to student achievement and student behavior, such as students' decision to be capable on subjects based on quantitative literacy.

Various topics in biology subjects can be integrated with quantitative literacy skills, including genetics, cell biology, biochemistry, plant growth and development, physiology, population dynamics, ecology, and many more [6]. This research chooses the topic of ecosystems. In line with research by [7], the topic of the ecosystem was chosen due to the usage of quantitative literacy skills in this topic by students.

Based on the previous description of the low level of quantitative literacy abilities, the effect of the students' attitude towards the use of mathematics to the quantitative literacy ability, and the demands of developing quantitative literacy-based ecosystem topic, then the study of biological-mathematical attitudes with quantitative literacy-based learning on ecosystem topic needs to be conducted. Therefore, the purpose of this study is to obtain information and to analyze students' attitudes towards the use of mathematics in biological contexts in learning a quantitative literacy-based ecosystem topic using the MBVI instrument.

2 Experimental Method

The research method used in this study is a quasi-experimental research design with Non-equivalent Control Group Design with pretest and posttest. The participants are students from two high schools in Bandung Indonesia in the 2018/2019 school year. The experimental class consisted of 65 students and the control class consisted of 66 students. In the control class, conventional ecosystem learning was conducted, while the learning of the quantitative literacy-based ecosystem was conducted in the experimental class.

Students in the experimental class observed the biotic and abiotic factors in the school environment. The observation data of temperature and humidity in the land ecosystems (parks), and observations of temperature and light intensity in the water ecosystems (ponds) at three different times are repeated three times for each. Students calculate the mean observations data of biotic and abiotic components in the ecosystems, represent the observations data of ecosystem components in the form of graphs, interpret observational data in mathematical form, and analyze the relationships between the components of the ecosystems

This research used two instruments, namely MBVI [2] given in the beginning and ending of learning process consisting of 25 items with a choice of responses ranging from "Strongly Disagree", "Disagree", "Neutral", "Agree", to "Strongly Agree". The instrument consists of 25 Likert-type test items related to four constructs, namely: the interest in using math to understand biology, the benefits or utility of math for the career path of science, the difficulties of incorporating math into biology courses, and the achievement score on math.

The benefit or utility subscale of the MBVI had a positive correlation with the subscale of the achievement score in math ($r = 0.52$, $p < 0.001$, $n = 205$). The items of students' interest on the two scales also shows an even stronger correlation ($r = 0.69$, $p < 0.001$, $n = 207$). The difficulties items from the MBVI were found to be negatively correlated with the scores on students' interest towards math ($r = -0.61$, $p < 0.001$, $n = 205$) and moderately negatively correlated with the scores benefits or utility on math ($r = -0.33$, $p < 0.001$, $n = 205$).

Quantitative literacy assessed by 15 multiple choice questions of quantitative literacy. Which consisted of 4 indicators, there are interpretation, calculation, representation, and analysis [8]. All tabulated data is presented as a percentage. The Mann-Whitney test was performed to analyze the differences of data in the two classes.

3 Result and Discussion

3.1 Quantitative Literacy

The percentage of quantitative literacy on the indicators of interpretation, calculation, representation, and analysis of students of both classes is shown in **Figure 1**.

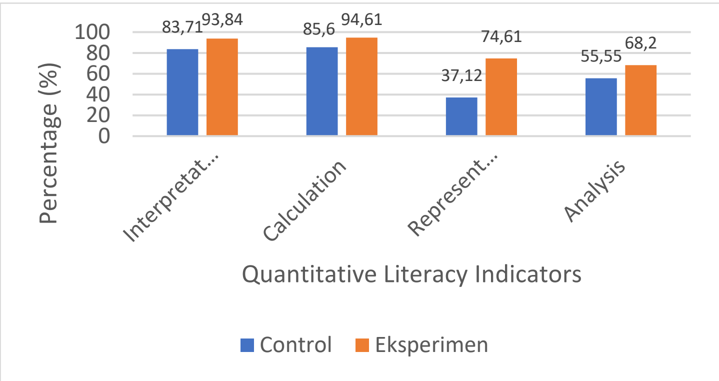

Fig. 1. Percentage of Posttest Score for Each Indicator of Quantitative Literacy.

The data in **Figure 1** shows that the students' quantitative literacy falls into the category of "good". There are only two indicators in the control class where the ability of students is in the category of "poor" and "fair", namely the ability of representation and analytical. The indicator that most students from both classes have is the calculation indicator. The normality test of posttest results is shown in Table 1.

Table 1. The result of Independent Sample t-test of posttest score.

Data Type		*Post Test*	
Class		Control	Experimental
Normality Test	Sig.	0,000	0,000
(Kolmogorov-Smirnov)	Int.	Tidak Normal	Tidak Normal
	Test Type	*Mann-Whitney*	

Data Type		*Post Test*
Independent Sample t-test	Sig.	0,000
	Int.	There is a significant difference

The normality test calculation results of the posttest show that the significance value of the control class is 0,000 and the significance value of the experimental class is 0,000, then the significance value obtained from the probability calculation of the posttest from two classes is $p < 0.05$. This shows that the quantitative literacy posttest data of the control class and the experimental class were not normally distributed. Based on the results of the t-test contained in Table 1, the value of Asymp. Sig. (2-tailed) = 0,000 <0.05 so H0 is rejected. Thus, it can be concluded that there is a significant difference between the results of the quantitative literacy ability posttest of the control class and the experimental class.

Quantitative literacy and the formation of cognitive schemes can be developed in an integrated and meaningful way through activities that involve students in the data gathering and data processing based on experience [9]. According to [3], students must have the ability to understand various mathematical representations to be able to make conclusions and decisions logically according to data. The results of this study indicate that quantitative literacy-based learning in the ecosystem topic significantly increases the ability of quantitative literacy in the experimental class.

3.2 Mathematical-Biological Attitudes

Students' mathematical-biological attitudes are shown in **Figure 2**.

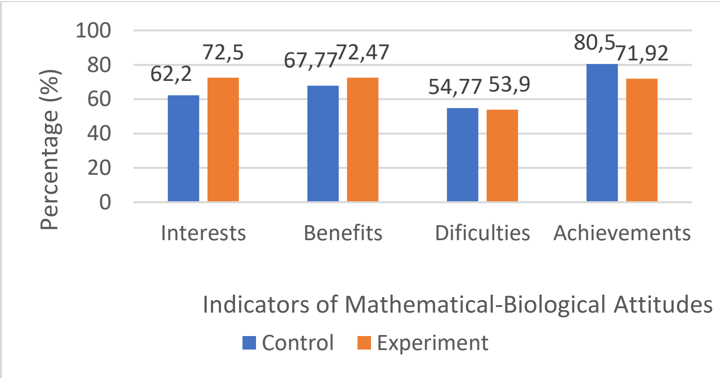

Fig. 2. The pretest score percentage of mathematical-biological attitudes indicators.

Based on **Figure 2**, students' mathematical-biological attitudes of each indicator in both classes can be categorized as "good" with more than half the students are interested, expressed benefits, and not experienced difficulties. Other indicators are included in the "very high" category with almost all students expressing the importance of mathematics. The indicator with the highest score in the control class is the indicator of achievement, and the highest score in the experimental class is the benefit indicator, which is 71.92%. While the indicator with the lowest score of the two classes is an indicator of difficulty experienced.

Andrews (2017) explains that some students with experience in using mathematics in biology can feel the difference in the benefits of mathematics in the mathematics subject, with

the use of mathematics in biology subjects. Thus, the initial mathematical-biological attitude of students is different. The higher interest and benefits indicators that students have caused their achievements to be higher as well. This is in accordance with the research of [2] who stated that students' personal values regarding the use of mathematics in biological contexts affect their achievement and behavior. According to [4] regarding the Expectancy-value Theory, mathematical-biological attitudes are important for the development of students' quantitative skills, because students' mathematical-biological attitudes are assumed to have an impact on student motivation. According to the Expectancy-value theory regarding the achievement motivation, student performance (for example, an achievement on quantitative assignments) depends on how well they expect to perform the tasks and target the scores they want to get.
Based on **Figure 3**, overall, indicators of students' biological-mathematical attitudes in the experimental class are included in the "good" category with almost all students interested, express the benefits, more than half experienced no difficulty, and almost all expressed the importance of using mathematics. While indicators of biological-mathematical attitudes of students in the control class are also in the "good" category with more than half of the students are interested, and express the benefits. The indicator with the highest score of both classes is the indicator of achievement. While the indicator with the lowest score of the two classes is an indicator of difficulty experienced. The posttest scores from the indicator with the highest score to the indicator with the lowest score respectively in the control class are the same as the experimental class, which are indicators of achievement, benefits, interests, then difficulties experienced.

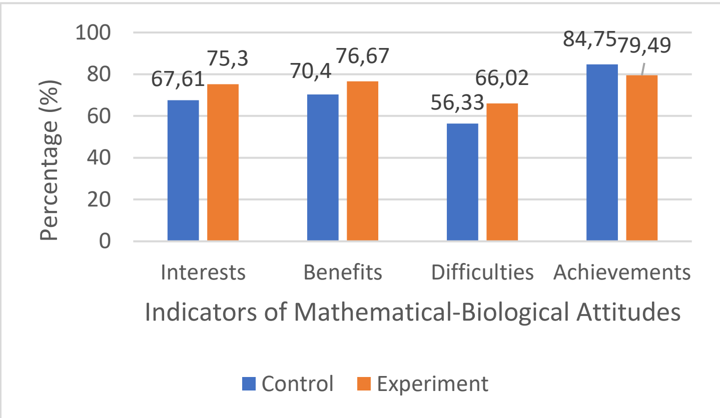

Fig. 3. The posttest score percentage of Mathematical-Biological attitudes indicators.

Eccles & Wigfield in [4] explains that in the Expectancy-Value theory, students' attitudes toward assignments are important as a predictor of achievement. Mathematical-biological attitudes of students are influenced by the learning process of quantitative literacy-based. This causes the mathematical-biological attitude of students in the experimental class tends to be better. In other words, quantitative literacy-based learning facilitates students to develop quantitative literacy skills that increase students' biological-mathematical attitudes. The increase was experienced by students in the experimental class but not experienced by students in the control class, because the learning process in the control class was not based on quantitative literacy, therefore the quantitative skills were not trained in the conventional learning [4].

The difficulties experienced that can be identified indirectly by feeling frustrated, overwhelmed by workloads, and students' description of the process of understanding the learning material is showing factors of difficulty [10]. Quantitative literacy-based learning using practicum methods facilitate students to develop quantitative literacy abilities, one of which is the ability to represent. This was experienced by students in the experimental class but not experienced by students in the control class, because in the control class, learning was based on conventional learning with practical methods and discussions, and not based on quantitative literacy so that quantitative abilities were not trained. Thus, quantitative literacy-based learning is more effective in overcoming the difficulties experienced by students regarding the use of mathematics in ecosystem concepts, as shown by the high increase in student representation abilities.

4 Conclusion

Mathematical-biological attitudes of students experience a positive improvement after learning through quantitative literacy-based learning on ecosystem topics. After the learning process, students in the experimental class have a quantitative literacy ability that is significantly different from students in the control class. Students in the experimental class have a very high level of quantitative literacy ability, while students in the control class have a high level of quantitative literacy abilities. Mathematical-biological attitudes in the experimental class show a positive effect from using quantitative literacy-based learning.

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