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Research Article

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Analysis of Students' Conceptual Understanding of Biology Material Based on STEM Learning

(Analisis Pemahaman Konsep Mahasiswa Pada Materi Biologi Berdasarkan Pembelajaran Berbasis STEM)

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ABSTRACT

The main objectives of biology learning are improving the mastery of concepts, understanding biology concepts in depth and applying them in problem solving processes. The aims of this research were to design a STEM-based Biology practicum module and evaluate its effectiveness on students' conceptual understanding. The method in this research followed a quasi-experimental research procedure, with a one group pretest and posttest design. This aims to obtain more information in understanding students' concepts after going through STEM-based biology practicum learning experiences. The research subjects were 36 junior high school students. Analysis of students' understanding of concepts is based on statistical descriptive data, normality test and paired t test and N-Gain. Based on the results of the research indicate that there is a significant effect of the application of STEM-based practicum modules on conceptual understanding. Besides that the N-Gain data shows an increase in students' understanding of concepts after being taught with the STEM-based biology practicum module. In this research, it has not specifically explained the model that is applied together with the STEM-based approach. It is important to do further research to design STEM-based learning with certain learning models.

Key words: *Conceptual understanding, Biology, STEM*

ABSTRAK

Tujuan utama pembelajaran biologi adalah meningkatkan penguasaan konsep, memahami konsep biologi secara mendalam dan menerapkannya dalam proses pemecahan masalah. Penelitian ini bertujuan untuk merancang modul praktikum Biologi berbasis STEM dan mengevaluasi keefektifannya terhadap pemahaman konsep siswa. Metode dalam penelitian ini mengikuti prosedur penelitian eksperimen semu, dengan *one group pretest* and *posttest design*. Hal ini bertujuan untuk memperoleh informasi lebih dalam memahami konsep siswa setelah melalui pengalaman pembelajaran praktikum biologi berbasis STEM. Subyek penelitian adalah 36 siswa SMP. Analisis pemahaman konsep siswa berdasarkan data statistik deskriptif, uji normalitas dan uji t berpasangan dan *N-Gain*. Berdasarkan hasil penelitian menunjukkan bahwa terdapat pengaruh yang signifikan penerapan modul praktikum berbasis STEM terhadap pemahaman konsep. Selain itu data *N-Gain* menunjukkan adanya peningkatan pemahaman konsep siswa setelah diajarkan dengan modul praktikum biologi

berbasis STEM. Dalam penelitian ini belum secara khusus menjelaskan model yang diterapkan bersamaan dengan pendekatan berbasis STEM. Penting dilakukan penelitian lebih lanjut untuk merancang pembelajaran berbasis STEM dengan model pembelajaran tertentu.

Kata kunci: Pemahaman Konsep, Biologi, STEM

INTRODUCTION

Basically biology is the science that studies living things from various aspects of problems and organizational levels and studies the structure and function of the human body's organs that work together to form a system, where in each system there are components that support each other (Astuti & Nurcahyo, 2019; Bruckermann et al., 2017). Biology learning is interaction of teaching and learning that occur between teachers and students in an education system through good communication by involving real biological objects and with the help of learning media (Dolan & Grady, 2010; Reinke et al., 2019).

Conceptual understanding is one of the key factors in science education (Aktan, 2013; Srisawasdi & Panjaburee, 2015; Sutopo, 2016) especially biology (Punyasettro & Yasri, 2021). Understanding concepts is an aspect of biology learning objectives at all school levels (Yürük et al., 2011). This is because an important goal in learning biology is to lead students to understand in depth the basic concepts in order to be able to apply them in problem solving (Wulandari et al., 2019).

There is a lot of biological material that has been the focus of several previous studies on conceptual understanding, for example on cell structure and function (Kete et al., 2012), the human reproductive system (Astuti & Nurcahyo, 2019), the Kreb cycle (Tanner & Allen, 2005), the concept of evolution (Punyasettro & Yasri, 2021), osmosis and diffusion (Reinke et al., 2019) and many other studies. Based on the findings in several previous studies, the difficulties experienced by students, among others, in understanding the cell concept, most students could not distinguish the fact that prokaryotic cells do not have a nucleus, and could not say the location of the endoplasmic reticulum (Kete et al., 2012). Even students argue that only protists have cilia or flagella (Kete et al., 2012). In research on the concept of reproduction, it shows that as many as 65 percent of students score below the KKM on the concept of the reproductive system (Astuti & Nurcahyo, 2019). In research on understanding the concepts of osmosis and diffusion, it shows that many students experience misconceptions in understanding the material (Reinke et al., 2019).

Several previous researchers have tried to implement several learning designs to overcome these problems. In Astuti & Nurcahyo's research (2019), developing flash media to increase students' understanding of biology concepts, but the use of flash media only increases student attractiveness, not understanding of concepts. In Sadeh & Zion's (2012) study which applied guided inquiry learning, however, many students still held wrong initial understandings even though they had gained inquiry learning experience. In Rahmat & Chanunan's (2018) study, which applied open inquiry, it was found that in implementing open inquiry, it is necessary to provide assistance in the form of scaffolding.

The learning process that takes place in the classroom is a manifestation of interaction between teachers and students, as well as student interactions with other students (Pérez et al., 2017). In order

to create this interaction, the teacher must plan the lesson well. The selection of learning strategies that can show and develop students' skills in learning is important, so teachers must master various learning strategies and be able to apply them according to learning needs. Errors in choosing learning strategies can lead to reduced motivation and student activity during the teaching and learning process (Reese-Durham, 2014).

Learning biology should be able to accommodate students' alternative conceptions of exploration to be explored and transformed into scientifically accepted conceptions (Freeman, 2012; Wulandari et al., 2019). The learning process like this is considered capable of increasing students' understanding of concepts. According to Smithenry (2010), learning is essentially a process of modifying ideas that already exist in students. Learning is the formation of understanding of experiences in relation to pre-owned conceptions. Learning occurs through the construction and elaboration of cognitive structures on the basis of previously acquired experience.

Ability in science and technology is very important for every student to have. This is because, one of the provisions that can be used to face life's challenges in the future is science and technology (Mulyani, 2019). The process of development of science and technology is increasing. The increased development and innovation of science and technology has resulted in qualified human resources capable of competing in the 4.0 industrial revolution era, which must be carefully prepared by each country (Micari & Pazos, 2012; Ogle et al., 2010).

The reality on the ground shows that there is a gap between science and technology in biology learning. This is due to the lack of implementation of biology learning by implementing existing technology. In learning biology, students are not only required to understand the material, but are also required to acquire skills in activating resources so that students can associate biological concepts with phenomena that exist in everyday life. Thus the teacher is required to be innovative in the learning process. One of the efforts that teachers can make to make it easier for students to understand the material is by using the STEM approach.

STEM is an interdisciplinary learning approach namely Science, Technology, Engineering and Mathematics. STEM is referred to as meta-discipline learning, because STEM integrates four disciplines into one comprehensive whole, with the aim of enabling students to learn academic concepts appropriately (Jang, 2016; Uzzo et al., 2018; Weintrop et al., 2016). This is because STEM-based learning requires students to carry out meaningful learning in understanding a learning concept by implementing technology into learning materials (Nugroho et al., 2019; Park, 2016). STEM-based learning can assist students in developing students' abilities to understand concepts (science), then be able to apply these concepts using skills (technology), based on existing concepts students are able to create a method (engineering/engineering), which is based on a calculation (mathematics) (Tecson et al., 2021). Based on the problems and theories that have been described, the researcher will design a Science, Technology, Engineering and Mathematics (STEM)-based Biology practicum module and evaluate its effectiveness on students' conceptual understanding.

The selection of STEM as the basis for the practicum module that will be designed is based on the data from the results of the needs analysis that has been carried out. The results of a conceptual study of several research articles show that the use of STEM aspects in teaching materials has an important influence on learning biology, namely being able to improve students' abilities including mathematical connection abilities, critical thinking, mastery of concepts, and scientific literacy skills.

Modules that contain STEM aspects are able to invite students to develop knowledge and find ways of learning that are appropriate to keep up with the times. Thus, the STEM aspect in the practicum module becomes important in learning

METHOD

The method in this study followed a quasi-experimental research procedure, with a one group pretest and posttest design. This aims to obtain more information in understanding students' concepts after going through STEM-based biology practicum learning experiences. The research subjects were 35 junior high school students. Analysis of students' understanding of concepts is based on statistical descriptive data, normality test and paired t test and N-Gain. Statistical descriptions are used to obtain data on maximum and minimum values, mean for each variable, median, standard deviation and skewness in the pre-test and post-test (Leech, et al., 2005). While the data normality test was carried out to determine the normality of the data before the pretest and posttest different scores were tested. The normality test was carried out using the Kolmogorov Smirnov test. Paired t test is used to see the difference in pretest and posttest scores if the data is normally distributed. According to Morgan, et al (2004), the two assumptions and conditions for using the paired t test are 1) dichotomous independent variables and levels or groups are paired (eg pre-post), 2) independent variables are normally distributed in two conditions. However, if the data is not normally distributed, then the differences in pretest and posttest scores are tested using the Wilcoxon test (Morgan, et al., 2004). To test the increase in students' understanding of concepts, it is calculated using the normalized gain score formula.

RESULTS AND DISCUSSION

This research aims to see an increase in students' understanding of concepts related to biology material after being taught with the STEM-based practicum guidance module. The increase in students' understanding of concepts after being taught with the STEM-based practicum guidance module can be seen from changes in pretest and posttest scores which were the results of the tests. The score for increasing understanding of the concept is expressed by the average value of N-Gain. The analysis was carried out in stages from determining descriptive statistics, conducting prerequisite tests, conducting statistical tests of differential power, calculating N-Gain and effect size. The results of descriptive statistics are presented in Table 1 which states the minimum, maximum, average, standard deviation and skewnes scores.

Table 1. Pretest and Posttest Descriptive Statistics

Statistik	*Pretest*	Posttest
N	36	36
Minimum	2,31	12,6
Maksimum	17,2	94.4
Mean	7,5	51,04
Standar Deviasi	4,06	22,29
Skewness	0,83	0,173

Table 1 shows the results of the increase in the minimum, maximum and average scores of the posttest on the pretest of students' conceptual understanding of biology material. From the average

score, it can be seen that there was an increase in students' conceptual understanding scores after being taught by learning with the STEM-based practicum guidance module from an average pretest 4score of 7.5 to 51.03 in the posttest. To perform a statistical test, first perform a prerequisite analysis test, namely the normality test. The results of the analysis prerequisite test using the Kolmogorov-Smirnov normality test for pretest and posttest data are presented in Table 2.

Table 2. Pretest and Posttest Data Normality Test Results

	Kolmogorov-Smirnov[a]			Category
	Statistic	df	Sig.	
Pretest	0,148	36	0,051	Normal Distributed
Posttest	0,109	36	0,2	Normal Distributed

Data from the Kolmogorov-Smirnov normality test results in Table 2 show that the pretest and posttest data of students' conceptual understanding is normally distributed. This is evidenced by the pretest and posttest significance values of 0.051 and 0.200 which are greater than the alpha value of 0.05. In addition, the skewness value in Table 5 shows a value of 0.83 for the pretest and 0.173 for the posttest. This value is between -1 and 1 which indicates that the data is normally distributed (Morgan, et al., 2004). Because the data were normally distributed, the differences in pretest and posttest students' understanding of concepts were analyzed using a parametric test, namely the paired t test. The results of the paired t test of differential tests, calculation of N-Gain and effect size are presented in Table 3.

Table 3. Difference Test Results, N-Gain and Effect Size Pretest and Posttest.

Statistics	**Scores**	Category
Nilai *t*	12,5	
Asymp. Sig. (2-tailed) (*Paired Sample Test*)	0,000	Significant differences, Posttest > *Pretest*
N-Gain	0,5	Medium
Cohen's d-effect size	2,1	Strong effect

The data in Table 3 shows that there was a significant increase in students' understanding of concepts after being taught with the STEM-based practicum guidance module. The paired t test results showed a t value of 12.5 with a significance level of 0.000. According to Morgan, et al (2004) if the significance is less than 0.05, the scores of students' understanding of concepts before being taught and after being taught with the STEM-based practicum guidance module are significantly different. In this case, students' understanding of concepts after being taught with the STEM-based practicum guidance module is higher than before being taught. The operational strength of implementing the STEM-based practicum guidance module towards increasing students' conceptual understanding is included in the strong category with an effect size value of 2.1. However, if seen from the magnitude of the N-Gain in Table 4.5, the increase in students' understanding of concepts after being taught with the STEM-based practicum guidance module is still in the medium category with an N-Gain value of 0.5..

CONCLUSION

Based on the results of the study indicate that there is a significant effect of the application of STEM-based practicum modules on problem solving abilities. besides that the N-Gain data shows an

increase in students' understanding of concepts after being taught with the STEM-based biology practicum module. In this study, it has not specifically explained the model that is applied together with the STEM-based approach. It is important to do further research to design STEM-based learning with certain learning models.

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