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Revealing the relationship between acceptance and understanding of evolution through NOS (Nature of Science)-based learning

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ABSTRACT

Evolution is considered as the central and unifying theme of the discipline of Biology. Yet, some debates refusing the theory of evolution raise and lead to a problem in understanding the evolution process. This study aimed to examine the relationship between acceptance and understanding of the concept of evolution in pre-service biology teachers with strong religious and educational backgrounds. A correlational design was employed in this current study. The study subjects were students of the Biology Education Department of Universitas Islam Madura, which has implemented NOS (Nature of Science)-based learning. All subjects are Muslims, and 86.84% pursued their education in Islamic boarding schools. The data was measured using MATE (Measure of Acceptance of the Theory of Evolution) and ECK (Evolution Content Knowledge). The study's findings indicate a significant relationship between acceptance and understanding of the concept of evolution. In addition, the acceptance of the concept of evolution contributed 63.6% towards the understanding. These findings suggest that acceptance of evolution is essential to understand it and that teaching evolution by implementing NOS-based learning is a necessary step to improve students' acceptance and understanding of the concept of evolution.

Introduction

Evolution is one of the underpinning principles of an understanding of Biology (Cofré et al., 2018; Glaze & Goldston, 2019; Kane et al., 2018; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000). Some recent studies have focused on teaching the concept of evolution because it is a foundation for understanding evolution and other frameworks of Biology courses. Ayala (2013) stated that having a good understanding of the concept of evolution helps to underpin the core concept of Biology. Principles of evolution are involved in other fields of study, such as medical science, public health, agriculture, conservation biology, natural resource management, and environmental science (Catley & Novick, 2009; Hendry et al., 2011; Nadelson & Hardy, 2015). Due to its importance in other fields, a famous

scientist, Dobzhansky, said, "Nothing in Biology makes sense except in the light of evolution" (Dobzhansky, 1975).

Many undeniable explanations related to the theory of evolution from scientific studies have been revealed, for instance, results from paleontological studies, ecological evolution, biological evolution, and the most increasingly developed study over the last century, molecular evolution (Bruner et al., 2017; Colautti & Lau, 2015; Skinner, 2015). Despite a lot of studies of evolution have been conducted and proven scientifically, this topic has remained controversial and has become the most misunderstood concept in Biology (Taylor & Ferrari, 2010). Misunderstanding and rejection to evolutionary theory commonly come from laymen (Heddy & Nadelson, 2012, 2013). Surprisingly, this phenomenon was also found among Biology educators and students in secondary and higher education level (Glaze & Goldston, 2015; Kim & Nehm, 2011; Metzger et al., 2018).

Some previous studies have identified some factors which cause different levels of acceptance to evolutionary theory. Barone et al. (2014) found that levels of acceptance were influenced by backgrounds of each individual such as education, financial income, political orientation, and religious beliefs. Another study conducted by Nadelson and Hardy (2015), revealed that trust in science and scientists affected the acceptance of evolution. In spite of various factors influencing the acceptance of evolutionary theory, religiosity was the main reason which underlies the lack of acceptance of evolution (Archila & Molina, 2020; McKeachie et al., 2002). More studies found that students having higher levels of religiosity tended to have less understanding and acceptance of evolution (Moore et al., 2011; Rutledge & Mitchell, 2002).

In Indonesia, a study about acceptance of the concept of evolution was still limited. Thus, this current study attempted to reveal quantitatively how the influence of religious beliefs on an individual's acceptance and understanding of evolution. This study was conducted in Madura, the northeastern coast of Java Island, whose people are famous for being religious and fully devoted to their beliefs. Moreover, the existence some of boarding school-based educational institutions could challenge educators to teach evolutionary concepts that might differ from other areas across the nation. Universitas Islam Madura, one of the boarding school-based universities in Madura, has been internalizing Islamic perspectives and values in students. It is obvious that the students of the university have an excellent understanding of their religion. Ironically, some students are difficult to accept, or even worse, reject the truth of evolutionary theory while studying Biology, as it contradicts their religious viewpoint.

The resistance to evolutionary theory is related to prior conceptions of students to evolution (Ingram & Nelson, 2006). Students' study goal focusing merely on their final exams also contributes to such attitude, because they only memorize lessons for preparing the tests, while their initial conceptions would remain in their memory (Nehm & Schonfeld, 2007). As a result, students are able to pass the tests, yet they still have misconceptions about evolution. If it happens to preservice biology teachers, they will probably pass on their misconceptions of evolution to their future students.

Some attempts have been made to improve students' understanding of evolutionary concepts. Mead et al. (2017) state that teaching genetics courses to students before delivering an evolution subject could increase their understanding, although it does not guarantee raising the level of acceptance. Another attempt is teaching genetics by using project-based learning (Fauzi & Ramadani, 2017), or by using Drosophila melanogaster as a model organism (Ramadani et al., 2016). Those are only a few examples of improving the understanding of evolution which need to be explored more to get a better result.

Studies of the correlation between acceptance and understanding of evolutionary concepts require the involvement of students of higher education level whose religious educational backgrounds are strong. Manwaring et al. (2018), explains that individual's religiosity can be measured from their religious behaviors such as their attendance at the worship place and the frequency of worship practice, the implementation of religious values in making decisions as well as perceiving life. In this study, receiving education from Islamic boarding schools is considered as a

good start for students as they have good understanding and abilities to implement religious values in their daily lives.

The correlation of acceptance and understanding of the concept of evolution should be studied from an implementation of some learning strategies which potentially can increase students' understanding and acceptance of evolution. The findings of previous studies indicated that evolutionary theory was well-received by scientific community (Bertka et al., 2019). For this reason, it is urged to teach evolutionary materials by demonstrating how knowledge is acquired, and understanding the way scientists think and work. An integrated learning, such as Nature of Science (NOS)-based learning, hopefully could increase students' acceptance and understanding of evolutionary theory. It is supported by Glaze and Goldston (2015), explanation that NOS-based learning delivers key concepts relating to understanding of science, acquisition, theories and research methods and roles of inferences and observations in science. Such concepts could be presented explicitly and implicitly to students while learning evolution and it is expected to influence their acceptance of evolutionary theory.

Method

This study employed quantitative method and correlational research design. The study was conducted during a semester by implementing Nature of Science (NOS)-based learning, involving 38 pre-service biology teachers' in Universitas Islam Madura academic year of 2019/2020. The acceptance of evolution was measured using MATE (Measure of Acceptance of The Theory of Evolution) developed by Rutledge and Warden (2000). The MATE instrument was used because it has been the most widely used assessment to quantify evolution acceptance around the world (reliability = 0.80), thus it would be great for comparing scores from this study to other samples. The questionnaire consisted of 20 items discussing 6 general concepts of evolution, such as: (1) the process of evolution, (2) scientific validation of the theory of evolution, (3) the evolution of primates, (4) evidence of evolution, (5) views of scientific community to evolution, and (6) the age of the Earth. The levels of acceptance of evolution were evaluated based on the MATE scores, presented in Table 1. A second instrument, the Evolution Content Knowledge (ECK), was used to determine students understanding of the key concepts of evolution. It was consisting of 21 multiple choice questions (reliability = 0.84). All questions were adapted from and adjusted to the scope of evolutionary concepts in MATE questionnaire.

The pre-test and post-test data of acceptance and understanding were tested statistically by using a simple regression analysis technique with a significance level of 0.05. Before testing the hypotheses, the assumptions testing, involving data normality test, auto correlation and linearity test, were also conducted.

Table 1. The levels of acceptance of evolution based on the MATE questionnaire

MATE Scores	Level of Acceptance
89-100	Very High Acceptance
77-88	High Acceptance
65-76	Moderate Acceptance
53-64	Low Acceptance
20-52	Very Low Acceptance

(Rutledge & Sadler, 2007; Rutledge & Warden, 2000)

Results and Discussion

In this section, the results of the assumption tests are presented. The result of normality test using Kolmogorov Smirnov test showed that the data normally distributed ($p = 0.200 > 0.05$). The DW value of autocorrelation test result using Durbin-Watson was 1.953, where was dU (1.5348) < DW < 4-dU (2.4652), meaning that there was no autocorrelation in the data of the study. Similarly, linearity test between acceptance and understanding of concepts showed that linear model was applicable for such correlation and there was no deviation in the linearity case ($p = 0.379 > 0.05$). It could be concluded that the assumption results met the requirement for testing the hypotheses using a simple regression analysis.

The results of the analysis of regression of acceptance and understanding of Biology students applying NOS-based learning were presented in Table 2, Table 3, and Table 4. The table of ANOVA summary was used to show the F value and significance level, the summary of regression was used for identifying the contribution of acceptance to understanding of evolution, while

coefficient regression was used for finding the regression equation of acceptance and understanding of evolution using NOS-based learning.

The analysis result presented in Table 2 shows that the F value was 65.594 with significance level of correlation between acceptance and understanding was p = 0.000 < 0.005, meaning that there was a significant correlation between acceptance and understanding of evolution using NOS-based learning. By implementing NOS-based learning, it is indicated that acceptance of evolution has potentially increased students' understanding of evolution.

Furthermore, the result presented in Table 3 shows that the correlation coefficient (R) was 0.804 with the reliability value (R2) was 0.636. It implies that 63.6% of a change of variable of understanding was caused by a change of variable of acceptance, while the rest, 36.4% of them, was caused by other variables that were not discussed in this study.

The equation of regression line between acceptance and understanding of evolution was based on Table 4, Y = 1.022X – 0.5206. The regression coefficient or slope was 1.022 shows that for every 1 digit increase of acceptance of evolution, understanding of evolution also increased by 1.022. Figure 1 shows the graph of the correlation between acceptance and understanding of evolution.

Figure 2 shown the total number and distribution of students in each level of acceptance before and after implementing NOS-based learning. The result of identifying acceptance of evolution using MATE questionnaire in pre-learning process showed the level of students' acceptance was in medium level. In the end of learning process, the number of acceptance level significantly increased. At the beginning, students showed a very low level of acceptance (10.53%), low level (26.31%), medium level (55.26%) and high level (7.89%) with average score was 65.13 or it was on the category of medium level of acceptance. In the end of learning process, the acceptance increased to the medium level (18.42%), high level (50%) and very high level (31.57%) with average score was 83.76 or it was on the category of high level of acceptance. It means that students' acceptance of evolution has been increased during the implementation of NOS-based learning.

Table 2. Summary of regression results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin–Watson
1	.804[a]	.646	.636	5.75867	1.953

[a] Predictors: (Constant), Acceptance of Evolution
[b] Dependent Variable: Understanding of Evolution

Table 3. Summary of anova results

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	2175.239	1	2175.239	65.594	.000[b]
	Residual	1193.840	36	33.162		
	Total	3369.079	37			

[a] Dependent Variable: Understanding of Evolution
[b] Predictors: (Constant), Acceptance of Evolution

Table 4. Regression coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.206	10.610		-.491	.627
	Understanding of evolution	1.022	.126	.804	8.099	.000

Dependent Variable: Understanding of Evolution

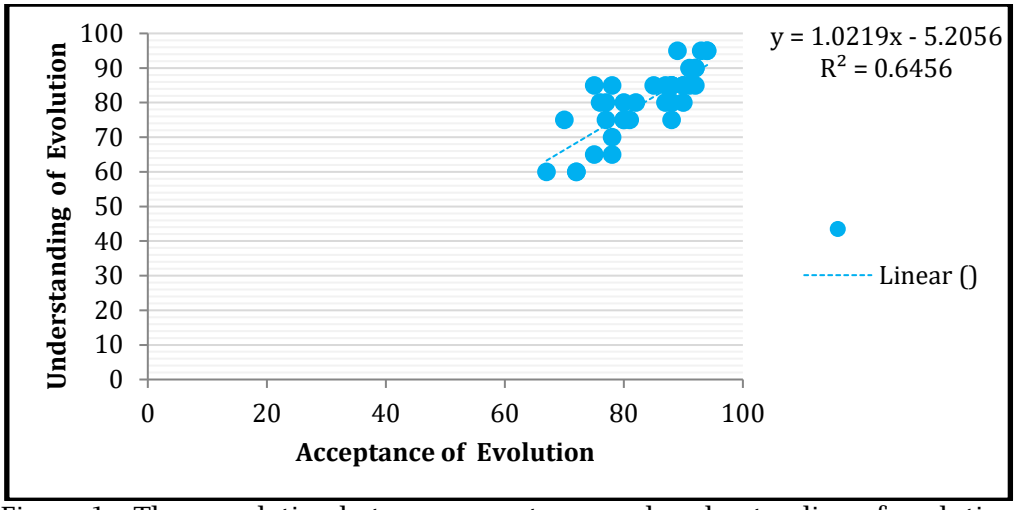

Figure 1. The correlation between acceptance and understanding of evolution

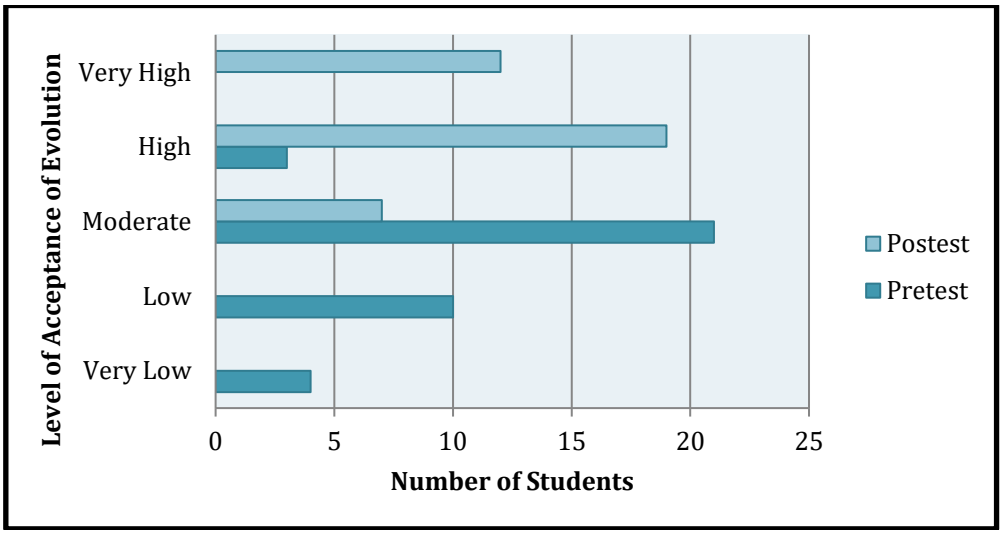

Figure 2. Students' acceptance of evolution level between pre-test and post-test

The finding of this study clearly showed that acceptance and understanding of evolution were correlated each other. It is supported Nadelson and Sinatra (2009); Nadelson and Southerland (2010) studies. Those previous studies, however, have not specifically revealed the relationship between students' acceptance and understanding of evolution and students' strong religious backgrounds. Therefore, the result of this study complements previous information that increasing students' acceptance of evolution is necessarily performed as it has been proven that acceptance was significantly correlated with understanding of students having strong religious backgrounds and has contributed 63.6%.

The concept of evolution is different from other concepts in Biology or science which could be easily accepted and understood. Taylor and Ferrari (2010), explain that having good understanding of other disciplines such as archaeology, genetics, heredity, ecology, geology and mathematical probability is needed to fully understand the scientific explanation of evolution. A complex understanding of evolution also needs some knowledge of science, probability and statistics, and geoscience (Gould, 2002). The concept of evolution is not only complex and abstract, but also gains a lot of controversial issues from different community. Owing to the reason, evolution subject becomes more challenging for both students as well as teachers and it is also a subject which raises more misconceptions (Pazza et al., 2010).

Some studies found that religiosity has become a general factor influencing

students' acceptance to evolutionary theory (Bertka et al., 2019; Manwaring et al., 2018; Nadelson & Hardy, 2015). The participants of this study were 100% Muslim and 86.84% of them, having boarding school educational background, and refused the theory of evolution because of the same reasons. The possible explanation for this situation is that the resistance to evolution is related to students' previous knowledge and understanding of evolution.

Generally, students have developed their conception of the process of creation based on their religious beliefs long before they learnt the theory of evolution at schools. They used to think that everything was intentionally created by a supernatural power. Unfortunately, their beliefs were not supported by their good understanding of the epistemology of science, so that they were overwhelmed when studying evolution (Evans, 2000, 2001). After evolution was introduced, the resistance of evolution increased together with lack of students' understanding of evolution. The lack of students' understanding was caused by lots of factors, as instances, the characteristics of evolution for being complex and abstract make students difficult to comprehend the concept, inappropriate learning strategy, as well as misconceptions from teaching materials and teachers. It is also worsened by students' study goal focusing merely on the success of final exam. They only memorized lessons for the time being, and they would forget everything and believed to their initial conceptions (Nehm & Schonfeld, 2007). According to Moore et al. (2011), students' learning process in Biology classes would significantly affect their attitudes in their next educational level. This is in line with the study of Athanasiou et al. (2016), reported that low acceptance of evolution was correlated with students' low educational background and understanding, as a result of their previous learning process.

There are indeed some complex situations for students to understand evolution comprehensively. Furthermore, misconceptions of evolution have lingered in their minds for so long. Taylor and Ferrari (2010), argue that if there is a bias in students' mind, it will be difficult to change.

Evolutionary theory does not oppose the existence of God. The aim of science and evolution is to propose logical explanations of natural occurrences based on in-depth studies. The theory of evolution, so far, has been the most accurate theory that could explain natural phenomena as the remnants of past life, such as the diversity of living things and the discovery of fossils from different era (Amin, 2015, 2016). There is no reason and objection claiming that God does not have any role in the evolution process, because He has been creating the diversity of living things and most of scientists also believe in God's power and His creation.

In addition, employing NOS-based learning enhances acceptance of evolution, and it improves students' understanding of evolution. The result of identifying acceptance of evolution using MATE questionnaire in pre-learning process showed the level of students' acceptance was medium (65.13). This is similar to the findings of (Glaze & Goldston, 2019; Ingram & Nelson, 2006; Rissler et al., 2014). However, the value of this present study was a way lower than the ones reported by Dunk et al. (2017) and Metzger et al. (2018). In the end of learning process, the number of acceptance level significantly increased on the category of high level of acceptance (83.76). It can be concluded that implementing NOS-based learning is very effective for increasing students' acceptance of evolution.

The raise of acceptance of evolution happened due to some aspects in NOS-based learning. The aspect of NOS understanding includes the understanding in which science is tentative; empirical; subjective; imaginative and creative; social culture; various research methods; and a relationship between a theory and scientific law (Hardianty, 2015). All aspects of NOS were studied implicitly and explicitly during a semester-long learning process. In learning NOS implicitly, students participated in investigation activities, so they improved their understanding of NOS, while the explicit learning was done by conducting reflective discussions about NOS aspects. For those who learnt NOS implicitly and explicitly for about one semester, they have become more open to scientific epistemology and started using NOS knowledge as their guidance to see and understand the concept of evolution, so that further misconceptions could be avoided. In the end, students were easier to understand

and accept scientific validation of evolution.

From the findings of this study, it is strongly suggested to teachers and lecturers to employ NOS-based learning as a framework to develop correct conceptions of evolution. The multifactorial findings from other study supported the findings of this study, in which the most influential factor of acceptance of evolution was students' understanding of NOS concepts (Dunk et al., 2017). Another study from Yasri and Mancy (2016), pointed that students in Thailand whose religious backgrounds were Christian and Buddhism confessed that their acceptance of evolution increased as their understanding of evolution and religious teaching improved. Those changes occurred after they learnt the differences between scientific views and religion views towards evolution. To conclude, NOS-based learning is an effective technique to improve students' acceptance of evolution.

Conclusion

By applying the NOS concept, pre-service biology teacher candidates with a strong religious background can increase their understanding of the concept of evolution and be wiser in understanding evolution and religious teachings. They admit that religion is a dogmatic belief, whereas evolution is tentative, empirical, and subjective due to the scientific method. Pre-service biology teacher candidates believe that the concept of evolution does not contradict the existence of God; instead, it can be a way to understand how God has created the diversity of living things. This research is still limited to pre-service biology teachers and has not been carried out in the realm of students.

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