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A Bootstrap Approach to Comparing Projects, Assignments, and Peer Tutors Methods on Science Performance through E-Learning

Siti Fatimah, Suhartono, Umi Mahmudah
[1]*Lecturer, Institut Agama Islam Nahdlatul Ulama of Kebumen, Indonesia*
[2]*Lecturer, Sebelas Maret University, Indonesia*
[3]*Lecturer,State Islamic Institute of Pekalongan, Indonesia*
Corresponding Author: stfatimah89@gmail.com

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ABSTRACT: This study aims to compare the learning methods of the projects, the assignments, and the peer tutors based on online-based learning. This study focuses on students' academic performance in science materials. This study uses a mixed-method, which is a combination of quantitative and qualitative methods. A type of sequential explanatory strategy is used. This study uses 241 students who are divided into three groups. The quantitative approach is carried out by using a test, projects, and assignments. Meanwhile, the qualitative approach uses both interview and observation. This study applies a bootstrapped-ANOVA to avoid misleading results due to the existence of the outliers. The results show that there are differences in the average academic performance of students on science materials based on the three methods. Besides, empirical evidence reveals the peer tutoring method provides the best results in science materials compared to the project and assignment methods. The result implies that educators can apply the peer tutoring method to improve student academic performance.

KEYWORDS: ANOVA, bootstrap, e-learning, learning methods, science.

I. INTRODUCTION

Currently, all countries throughout the world are struggling with Coronavirus (Covid-19). Because of its rapid and comprehensive spreading, it is declared as a global pandemic by the World Health Organization (WHO). As a precaution, the Indonesian government issues various policies to limit physical contact, namely social and physical distancing to break the chain of the spread of the Coronavirus. This virus has affected all aspects of life, including education. The face-to-face method that is usually applied during learning has to be replaced by distance learning using an internet connection, which is often called e-learning. It is one of the best solutions to keep the education system in Indonesia running well (Fatimah & Mahmudah, 2020).

OECD defines e-learning as the application of information and communication technology in a variety of educational processes to support and enhance the learning process in higher education institutions. This includes the use of information and communication technology and online learning, or both, to complement the traditional classrooms or face-to-face method (OECD, 2005). E-learning is a learning system using internet technology to improve knowledge and performance (Jethro et al., 2012). Figure 1 shows the characteristics of e-learning, where there are four main characteristics, namely accessibility, flexibility, communication digitally, and interactivity (Algahtani, 2011).

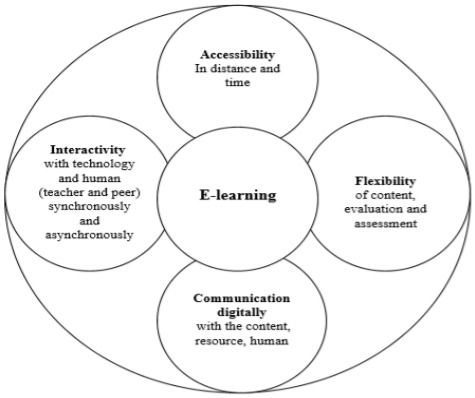

Figure 1. The Essential Characteristics of E-Learning
(Source: Algahtani, 2011)

The use of e-learning systems is believed to have many advantages (Alqahtani & Rajkhan, 2020; Bayani et al., 2017; Elfaki et al., 2019; Elzainy et al., 2020; Fatimah & Mahmudah, 2020; Hoq, 2020; Radha et al., 2020). The system can make students learn materials independently. A good design of e-learning can motivate students to be more involved in the learning process (Fatimah & Mahmudah, 2020). Then, the system is also known for its flexibility, not limited by space and time (Hamid et al., 2017). Through e-learning, students are no longer fixated on the delivery of materials provided by educators directly (face-to-face) but students may be more open to receive and search for materials by using the internet (Fatimah & Mahmudah, 2020). Other advantages of e-learning, namely students can learn independently, anytime, anywhere, with any background, saving time and money (Arkorful, 2014; Bayani et al., 2017; Burns & Kurtoğlu-Hooton, 2016; Fatimah & Mahmudah, 2020; Radović-Marković, 2010). E-learning provides better efficiency because students receive knowledge, skills, and attitudes faster than the traditional methods. This efficiency tends to translate into better motivation and performance (Jethro et al., 2012). E-learning can improve student achievement and attitudes better than traditional learning (Elfaki et al., 2019). Also, e-learning may change the teacher-centered learning paradigm to be student-centered (Yusuf & Al-Banawi, 2013).

In times of a pandemic like today, where all learning uses an online system, educators are required to be able to adapt quickly and precisely. Various learning methods that are usually used in traditional learning systems can also be tried to be applied in the e-learning model, such as project methods, peer tutoring, and assignments. There have been many studies that discuss online-based learning methods. However, only a few were found to compare the effectiveness of the three methods in science material (Daradkeh et al., 2019; Papanikolaou & Boubouka, 2010; Watcharapunyawong, 2018). One of the e-learning methods to involve the role of both teachers and students to learn creatively is to use the method of the project (Daradkeh et al., 2019). Project-based e-learning uses the principles and rules of the project method, but all the processes are carried out through e-learning. Through project-based e-learning, there are many benefits obtained by students. They can carry out projects independently; students actively develop knowledge, abilities, and skills from a variety of literature. Therefore, students can strengthen their activities and cognitive abilities (Daradkeh et al., 2019). The project stage of learning is very important for cultivating students' metacognitive abilities (Papanikolaou & Boubouka, 2010). Students who do experiments directly have the best understanding of science material (Eskrootchi & Oskrochi, 2010). Apart from the project method, the peer tutoring method can be used to make the learning process more fun and less monotonous. The peer tutors method based on e-learning can improve students' academic abilities and at the same time increase a high sense of responsibility. Also, student satisfaction with e-learning using peer tutors methods is higher than traditional learning (face-to-face). High collaboration between students can increase their motivation and confidence (Watcharapunyawong, 2018).

However, few studies have been found comparing the effectiveness of some of these methods, particularly in science learning. Therefore, this study aims to compare the effectiveness of three online-based methods, namely assignments, projects, and peer tutoring which are then linked to students' academic performance in science materials. This research is expected to provide empirical evidence that can be used as an academic reference in determining online learning designs, especially in science learning. Therefore, educators are able to create interesting and enjoyable e-learning methods. So, it can have direct implications for the quality of learning, which is closely related to the level of students' understanding of the materials presented by the educators.

II. METHODS

This study uses mixed methods where both quantitative and qualitative methods are combined. Mixed methods are a type of research involving philosophical assumptions that data collection and analyses are carried out using a mixture of qualitative and quantitative approaches in many phases of the research process (Creswell & Creswell, 2018). This study uses a type of sequential explanatory strategy of mixed methods, which is an approach that tends quantitative processes. Thus, the first stage is the collection and analysis of quantitative data which is then followed by the collection and analysis of qualitative data in the second stage. It is important to note that the steps in the second stage are built based on the initial results of the quantitative approach. Therefore, quantitative data is prioritized throughout the entire analysis process (Creswell & Creswell, 2018).

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The first step is to design quantitative research by determining the research subjects to be used as samples. This study uses 241 students at three universities in Indonesia who take courses related to science materials. It should also be informed that all respondents in this study are not students majoring in science. Quasi-experimental research is used to compare three methods in e-learning, namely the projects, the assignments, and the peer tutors methods on students' academic performance in sciences. Thus, students are designed to be three groups. Each group is subjected to different treatment, which is based on the learning methods used by educators. The learning process on science materials is carried out six times, all of which use e-learning systems.

To see the effectiveness of the three methods, this study uses the average score of students on science materials based on the methods imposed on them. Moreover, to measure their performance on science materials, this study uses research instruments in the form of tests, assignments, and projects. To see the difference in the effect of the three methods on student academic performance on science materials, this study offers the following hypothesis.

H0: There is no difference in project, assignment, and peer tutoring methods on science materials.
H1: There is a difference in project, assignment, and peer tutoring methods on science materials.

To obtain empirical evidence in analyzing the comparison of the effectiveness of the three methods, this study applies a bootstrap approach to the analysis of variance (ANOVA). A bootstrap approach is a nonparametric approach based on re-sampling. This approach is believed to provide better accuracy than ordinary statistical methods (Efron, 1979). Because this is a non-parametric approach there is no need for normally distributed data (Chernick & LaBudde, 2014; Eck, 2018; Efron, 1979; Fox & Weisberg, 2012). Furthermore, the bootstrap approach can overcome the adverse impact of the existence of outliers on research data (Chernick & LaBudde, 2014; Mustakim et al., 2019; Simar & Wilson, 1998).

The second stage is to analyze these quantitative results using a qualitative approach. Triangulation techniques based on Miles and Huberman are used, which are data reduction, data presentation, and drawing conclusions or verification (Miles & Huberman, 1994). In the second stage, the empirical evidence that has been obtained from the first stage is used to gain a deeper understanding of the effectiveness of the three learning methods. Thus, observations and interviews with several students are carried out by the educators to obtain relevant qualitative data.

III. RESULTS AND DISCUSSION

This section provides empirical evidence of the effectiveness of the three methods used in online learning on science materials, namely the projects, the assignments, and the peer tutors methods. The general description of the respondents analyzed in this study is as follows. The average age of the respondents is 20 years. The oldest and youngest respondents are known to be 23 years and 18 years, respectively. Most of the respondents are female, namely 63.25%. Meanwhile, male respondents are 36.75%. Then, the majority of respondents are known to be in their second year at university. Table 1 shows the distribution of respondents based on online-based learning methods imposed on them.

Table 1. The Distribution of Samples

Methods	Samples
Projects	69 students
Assignments	87 students
Peer tutors	85 students

Table 1 indicates that the sample distribution based on the method treated to students is uneven. The method of assignment is known to be imposed on the majority of respondents, which is 36.10%. Then, peer tutors and project methods are imposed on students as many as 35.27% and 28.63%, respectively. Therewith, it is known that the average score of all respondents' academic performance on science material is 80.50 out of 100. Moreover,

the highest and lowest scores are 62.60 and 88.90, respectively.

Table 2 shows a statistical description of the respondents' academic performance on science materials based on the online-based learning method applied to them.

Table 2. Descriptive Statistics on Science Performance

Statistics	Projects	Assignments	Peer Tutors
Minimum	62.60	71.50	73.20
Maximum	83.00	84.67	88.90
Average	80.41	79.82	81.26
Std. deviation	3.72	2.64	2.61

Based on all the descriptive statistical values in table 2, it indicates that the peer tutoring method is the most effective compared to the other two methods applied to students in online learning-based science materials. Hereafter, table 2 also shows clearly that the peer tutoring method produces the highest average score of student academic performance in science while the assignment method provides the lowest average score.

The results of the preliminary data screening show that the student's academic performance on science materials is known to be contaminated by outliers. They are the extreme values that may affect the accuracy of the estimated results. Figure 2 shows the results of detecting outliers on students' science performance scores.

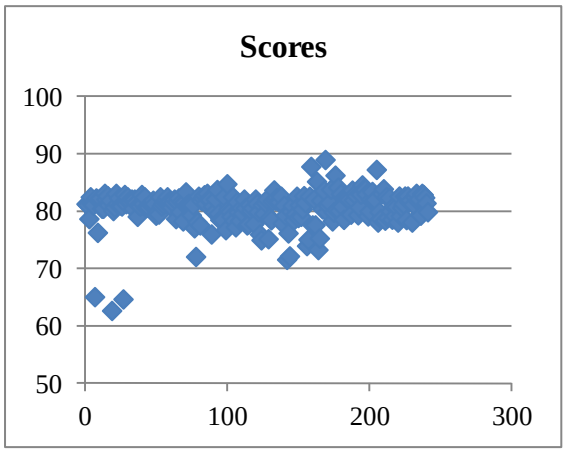

Figure 2. Outliers Detection

Scores
100
90
80
70
60
50
0
100
200
300

Figure 2. Outliers Detection

From Figure 2 it can be seen clearly that some of the students' scores gave scores that were too small or slightly larger so that they are outside the data set. These extreme values may produce misleading analysis results. Therefore, an alternative approach, such as the bootstrap approach, is needed to overcome this problem (Chernick & LaBudde, 2014; Eck, 2018; Efron & Tibshirani, 1994; Härdle & Simar, 2013). Aside from that, the normality test using a Kolmogorov-Smirnov (K-S) test also indicates that the data used in this study are not normally distributed, as presented in Table 3.

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Table 3. Normality Test

		Scores
N		241
Normal Parameters	Mean	80.4985
	Std. Deviation	3.02998
Most Extreme Differences	Absolute	0.131
	Positive	0.130
	Negative	-0.131
Kolmogorov-Smirnov Z		2.032
Asymp. Sig. (2-tailed)		0.001

The K-S test in table 3 provides a significance value of 0.001, which is smaller than 0.05 so it can be said that the scores of students' performance in sciences are not normally distributed. Based on Figure 2 and Table 3, the traditional ANOVA is not recommended. Thus, a bootstrapped-ANOVA is more appropriate to be used to compare the learning methods on science materials, namely the projects, the assignments, and the peer tutors methods.

Table 4 shows the estimation results using both the bootstrapped-ANOVA. The number of sample replications used in the analysis of the bootstrap approach is B = 1000. This study also uses a bootstrap residual type to produce the estimation results. The total degree of freedom (*df*) is 140, where the degree of freedom between groups is 2. Then, the degree of freedom within groups is 238. It is important to note that the number of degrees of freedom depends on the number of sample sizes and the number of variables.

Table 4. Bootstrapped-ANOVA

F	**SSE**	**SSTr**	***p*-value**
5.04	2097.62	17.40	0.00

From table 4, *F* represents the *F*-statistic value by type I sum of squares, *SSE* indicates the sum of squares error from type I sum of squares, and *SSTr* shows the sum of squares treatment from type I sum of squares. Based on table 4, it is clearly seen that the bootstrap approach on ANOVA can provide a good estimation result. This can be seen based on *p*-values, which is 0.00.

Based on table 4, the results of the analysis using the bootstrapped-ANOVA approach decide to reject the null hypothesis (H0) because the *p*-value is less than 0.05. Consequently, the conclusion of this study is to accept the alternative hypothesis (H1). From the previously offered hypothesis, it is known that the H1 statement is "*There is a difference of project, assignment, and peer tutoring methods on science materials*".

Therefore, the results of the analysis suggest that that the project, assignments, and peer tutors methods have significant differences in producing student academic performance on science materials. The difference in the use of these methods is known to have a positive and statistically significant effect on students' performance in science materials. In other words, there are significant differences in an average performance in science materials when the students are treated with different e-learning methods. These results are supported by previous researches, which report that different learning methods tend to provide different academic performance (Alghamdi et al., 2020; Arnold et al., 2020; Waheed et al., 2020; Yi & Lim, 2020).

Because the hypothesis decision is to reject H0 then a Post Hoc test is necessary. Table 5 shows the results of the post hoc test on ANOVA.

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Table 5. Post Hoc Test

(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower	Upper
Projects	Assignments	0.58	0.48	0.45	-0.55	1.71
	Peer tutor	-0.86	0.48	0.18	-1.99	0.28
Assignments	Project	-0.58	0.48	0.45	-1.71	0.55
	Peer tutor	-1.44*	0.46	0.00	-2.1	-0.36
Peer tutors	Project	0.86	0.48	0.18	-0.28	1.99
	Assignments	1.44*	0.46	0.00	0.36	2.51

the Post Hoc test in table 5 shows there is a significant difference in the average academic performance of students on science materials based on the assignment and peer tutoring methods. From table 5 it is known that the significance value is less than 0.05, namely 0.00. Based on table 5, it can also be seen clearly that the average difference between the two methods is 1.44, which is quite significant. Other than that, the Post Hoc test also indicates that there is no significant difference between the project method with the assignment method and peer tutors in the academic performance of students in science material. Based on table 5, the significance value between the project and the assignment method is 0.45. Meanwhile, the significance value between the project and the peer tutoring method is around 0.18. Both numbers are greater than 0.05.

Figure 3 shows the Means plot for the three methods used in this study.

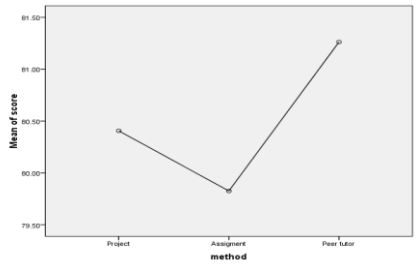

Figure 3. Means Plot

Figure 3 provides a clearer illustration related to the difference in the average performance of science-based e-learning. This shows the Means plot for all three methods.

Looking deeper into the data it is also found that the majority of respondents (around 63.07%) have higher academic performance scores on science materials than the overall average score. Furthermore, the peer tutoring method also provides the highest score among students whose science performance is above the average score, namely 36.18%. Nevertheless, the difference between peer tutors and project methods is not too far away, which is only around 1.32%. However, the difference between peer tutors and assignment methods is quite high, which is at 7.24%.

Thus, based on this empirical evidence, it is safe to state that peer tutoring is the best method of providing student academic performance on science materials compared to assignment and project methods when the learning process uses an online-based system. In other words, the peer tutoring method is the most effective method in online-based science learning. This statement is also supported by evidence that the peer tutoring method provides the highest average score on student academic performance in science as given in Table 2 and Figure 3. The results of this study do not contradict the findings of previous studies which state that the peer tutoring method is one of the best methods that can be used to improve student academic performance (Alegre et al., 2019; Arco-Tirado et al., 2020; Kim et al., 2020; Moeyaert et al., 2019).

The peer tutor method is closely related to learning styles that emphasize the learning process on the relationship between students. Thus, table 2 also indicates that students feel more comfortable in discussing, asking, and

giving opinions among peers compared to their lecturers. Discussions with peers tend to increase students' comfort and confidence in learning science material (Chien et al., 2020; Eddy et al., 2015; Martin et al., 2020). A comfortable relationship between students and the same learning opportunities is needed in the science learning process so that the resulting output is optimal (Darling-Hammond et al., 2020). Therefore, the peer tutor method provides excellent student performance in science learning.

Based on observations and interviews by educators, it is known that the peer tutors method can create a better online learning environment than project and assignment methods. Besides, the results also show that the peer tutors method tends to be more able to improve students' activeness. Through peer tutors, students tend to participate more actively and may provide appropriate arguments so that they can improve students' academic achievement. A study reports that online learning with the peer tutors method may increase students' participation actively (Sansone et al., 2018). The use of the online peer tutors method can improve academic achievement and scientific knowledge of students (Chu et al., 2017).

However, students face various difficulties when the peer tutoring method is applied through e-learning. Interviews with several students indicate the absence of opportunities for face-to-face discussions with peers is a major obstacle in this method. Even though they can use technology such as video calls, they still feel uncomfortable. Then, students also need more time and energy in applying this method. A comfortable and supportive environment affects student science learning outcomes through e-learning, such as increasing metacognitive abilities (Papanikolaou & Boubouka, 2010). Nevertheless, most students state they prefer the peer tutors method in science materials through e-learning. The use of peer tutors methods in small groups, such as 3-5 students, is also able to increase the activeness of all group members.

The empirical results also reveal the assignment method provides the lowest academic performance in science materials by using e-learning as presented in Table 2 and Figure 3. In this method, students are only given assignments by the lecturers without any discussion activity. This method focuses on the results of student assignments rather than the discussion process. The absence of discussion activities between lecturers and students causes a lack of understanding and activeness in students. The interview results indicate the assignments method based on e-learning is more in demand by students because the level of complexity of the work is lower than that of the peer tutors and the methods of the project. They prefer the assignment method over the projects and the peer tutors methods because this method tends to give them the freedom to complete assignments independently. It is one of the advantages of using the assignment method in e-learning. On the other hand, the assignment method does not provide an opportunity for students to develop cognitive skills and knowledge. The observation results also indicate that most students in carrying out the assignments from the lecturer are perfunctory so that the results are not optimal.

The peer tutors method may develop students' knowledge, improve the character of responsibility, social relations, and perseverance. Meanwhile, the project method can provide opportunities for students in analyzing and finding solutions by themselves. Through online learning, the project method can accelerate students in understanding a science concept by searching literature from various sources (Daradkeh et al., 2019). Furthermore, the assignment method produces a positive impact on skills and increases students' academic achievement (Songsirisak & Jitpranee, 2019). Internet connection becomes a powerful media and is widely used by students in completing assignments. Nevertheless, it is undeniable that the assignment method affects students psychologically (Songsirisak & Jitpranee, 2019).

The project learning methods have weaknesses in time efficiency, which requires a lot of time so that causing the reflection phase

at the end of the project to be less than optimal (Daradkeh et al., 2019). The project methods tend to focus solely on project completion but lack of discussion among teachers and students so that students are less able to absorb the material properly. The results of interviews with students reveal that the e-learning-based project method, which is carried out independently, is felt to be more difficult. Therefore, the project method through e-learning should be done in groups. Besides, the discussion time on this method is also very limited because it is constrained by space and time so that the absorption of students' science materials is less optimal. The project report that must be done also makes students more stressed because they have spent a lot of time and energy on completing the project. Unfortunately, the project method requires students to be able to complete both projects and their reports. Consequently, students are less than optimal in preparing reports. Presentation sessions take up too much time because each student presents the results of his project; therefore the learning time is finished before there are clarification and discussion with the lecturer. Overall, the project method in science materials that are carried out independently is less effective in e-learning. However, the project method has the advantage of being able to provide hands-on experiences. Also, students can make their creations and products.

Although the peer tutoring method is proven to be able to provide good performance outcomes in science materials, there are various obstacles faced by students during the online-based learning process (Alqahtani & Rajkhan, 2020; Elzainy et al., 2020; Hoq, 2020; Radha et al., 2020). Some of the difficulties faced by students based on the results of observations and interviews are as follows: (1) e-learning system forces the students to study extremely hard compared to the face-to-face method; (2) they have difficulty in understanding the science concepts without direct guidance from the lecturers; (3) e-learning is a relatively new system for most students so they find it difficult to adapt; (4) they are less comfortable learning science materials through e-learning; (5) an unstable internet connection has always been a technical obstacle for students in online learning; (6) e-learning system also spends too much money on internet connection. These various reasons make students prefer the conventional learning method, which is the face-to-face method in the classroom (Fatimah & Mahmudah, 2020; Hoq, 2020; Radha et al., 2020).

IV. CONCLUSION

This study focuses on the use of e-learning in science materials as a result of the coronavirus pandemic that is sweeping the world. It is understandable if e-learning is not properly applied to science materials, especially the abstract ones. Comparison of three learning methods, namely the projects, the assignments, and the peer tutors are analyzed using the bootstrapped-ANOVA approach. By using a mixed-method, this study provides both empirical pieces of evidence and in-depth discussion.

The empirical results suggest that there are significant differences in the average performance of the three methods of student performance in learning science materials. The results also indicate that the peer tutors method is the most effective method to learn science materials through e-learning. However, the assignment method is the most popular among students even though it provides the worst performance. Consequently, to get better student academic performance, the peer tutoring method should be tried to be applied in online-based learning.

Furthermore, the results also reveal there are obstacles faced by students in learning science materials through e-learning. Minimal guidance and discussion with lecturers make it difficult for them to understand the materials deeply. Therefore, they are forced to study immensely hard to understand science materials. Researches on other learning methods can be analyzed to determine their effectiveness in learning science materials based on an online system. Therefore, they can enrich references for educators to be able to make the best learning designs, which affect student learning outcomes.

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