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The Effect of STEM integrated with Project Based Learning (PJBL) Model of Respiratory System Material to Students Activities and Learning Outcomes

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Abstract. It is critical to understand how to enhance students' activities and learning outcomes; various research have shown that combining PBL with stem may enhance students' activities and learning results in the classroom. This study aimed to confirming the effect of project-based learning model integrated with STEM in respiratory system material in the activities and learning outcomes. The study was conducted in 11th grade of Natural Sciences class at MAN 1 Jember, East Java Indonesia 2019/2020 academic year. This study used a quantitative approach with a non-equivalent group post-test only design. Purposive sampling technique was used in this study. Tests, documentation and questionnaires were used as data collection techniques. The process of data analysis was done by using the Mann-Whitney U test. According to the Mann-Whitney U test findings, there was a substantial difference in student achievement between both the experimental group and the control group (Sig. 0,000), with the experimental class's average value being 85.42 higher than the control class's average value of 75.36. Thus, this study reinforces previous studies indicating that a STEM-integrated project-based learning paradigm has a significant effect on activities and learning results.

1. Introduction

Because living in the twenty-first century requires a range of abilities, it is believed that education can enable students to acquire them in order to be successful in life. In the twenty-first century, critical skills remain essential for the four pillars of life: learning to know, learning to do, learning to be, and learning to live together. Each of the four principles has particular abilities that must be developed throughout learning activities, including critical thinking, problem solving, communication, teamwork, creativity and invention, and literacy. These 21st century skills can be acquired by improving the quality of learning, assisting students in developing participation, adjusting learning personalization, emphasizing problem or project-based learning, encouraging collaboration and communication, increasing student engagement and motivation, cultivating a culture of creativity and innovation in learning, utilizing the appropriate learning facilities, and desiring [1].

Learning is a process of absorption of information from teachers by engaging certain activities and actions or treatments to achieve the goal of better learning outcomes. Learning outcomes is the end result of the students' learning process after they complete a certain instructional unit [2]. The learning success is not only seen from the final grades obtained by students but also seen from the learning process. The learning model used by teachers is one of the factors that influences the learning result.

The respiratory system is an abstract and quite difficult biology subject because there are things that concern concepts, processes, symptoms or anything that occur in the body in daily life. Students can't see these things directly. That condition causes students to experience a decrease in learning interest due to lack of understanding, thus impacting the activeness and learning outcomes of the students. Therefore, there is a need for innovation to increase students' understanding and to create an interesting and enjoyable atmosphere in the learning process. It also makes them understand science and its connection to natural phenomena [3].

Students' learning does not rely just on the teacher's expertise or content from the textbook [4], it requires a valid and dependable learning model or strategy. Based on the problems above, the learning strategy used in the classroom must be changed by applying a more varied learning model, one of which is to apply a project-based learning model. The Project-based learning is the ideal learning model to meet the educational goals of the 21st century, as it involves in the principles of 4C namely critical thinking, communication, collaboration and creativity. The research result on project-based learning and problem-based learning shows that they benefit the students to learn factually rather than learning in more traditional classrooms. However, in order for project-based learning and problem-based learning to work well, teachers must design an activity plan that suits students' interests and needs, and is of course tailored to the curriculum [1].

Improving the quality of education can be done through the implementation of education reform. One form of education reform can be done by using a learning approach that can help teachers in creating experts namely STEM approaches. Integrated STEM learning from science, technology, engineering and mathematics through technology, teaching, engineering and learning strategies can encouraged student to not only understand science concept but also apply it. STEM (Science, Technology, Engineering and Mathematics) can flexibly integrated with learning models, it also can improve learner knowledge and is able to create solutions in solving rapidly changing problems in the future. So that in the learning implementation, if the learner is given a task, they can be expected to understand it, and apply the concept that is being learned to obtain the results and solutions of the problem or task [5]. Lee et al. examined the influence of a companion strategy or learning model in enhancing the efficacy of STEM classroom sessions. Lee et al. discovered that STEM lessons integrated with another technique or technique (e.g., project-based learning or the 6E learning model) were more successful than STEM lessons alone [6]. STEM education is implemented in a variety of methods around the globe, including Asia. Certain learning methodologies or models are integrated and/or juxtaposed with STEM enactment; for example, the researchers enacted STEM education using project-based learning, problem-based learning, or the 6E learning model. This combination is necessary to maximize the anticipated benefits of STEM education [7].

Project-based learning was shown to be the most often employed strategy in STEM subjects. Create-based learning is a kind of project-based learning that targets significant real-world challenges and enhances students' subject learning by allowing them to engage, do research, design, and discover solutions. According to the meta-analysis, thirteen publications fit the requirements for STEM education's project-based learning strategy. These criteria included active learning, student engagement, the ability to develop critical thinking skills through the exploration of real-world situations, and the ability to develop solutions upon project completion. They concluded that integrating project-based learning into STEM education had a positive impact on meaningful learning, thereby assisting students in developing their confidence in choosing STEM careers in the future. Thus, students develop experience learning via cooperation, strengthening their presenting abilities and ability to generate solutions for their assignment. As a consequence, educators and instructors should ensure that their project-based learning programs are well-planned, authentic, complicated, well-defined, and focused on the student [8].

Development in education may take the shape of new models, methodologies, instructional media, and teaching texts [9]. Integrating project based learning model with STEM is is one kind of innovation in the academic domain. Several previous relevant studies have shown that the implementation of STEM-integrated project-based learning models in biology learning on the theme of environmental pollution has a very positive response from students and is effective to apply. Hypothetical tests showed that there were significant differences between the experiment class and the control class, it also found that science literacy, creativity, and learning outcomes in the experiment class were better than the control classes thus the STEM integrated project based learning model had an effect on science literacy, creativity and learning outcomes of students at SMAN 11 Sinjai [10].

The results of Lani Meita Indah Furi's research, show that learning using stem integrated project-based learning models can improve the results of cognitive aspects, which can be seen from high N-gain scores compared to using project-based learning models. It also can improve the learning outcomes of psychomotor aspects, which can be seen from the difference in grade of the skills when conducting milk-processed practices. by using stem integrated project-based learning model, the average value of creativity assigned to students in the fundamental competence of milk processing technology is greater than in the project-based learning model. [11].

Mustafa, Ismail, Tasir, Said, and Haruzuan performed another study in which they examined successful techniques for integrating STEM education internationally for a variety of reasons, including student learning outcomes. According to this research, the most successful technique for implementing STEM education in Asian nations was project-based learning; particularly, research focused on students in the secondary setting. Additionally, some recent studies examined the research trend in STEM education. The findings indicated that research in STEM education is gaining worldwide prominence and is becoming a truly multinational discipline [12]. While the research conducted by Ines Dwi Astuti, Toto, and Lia Yulisma found that STEM integrated project-based learning (PjBL) models can increase the mastery of student concepts in high-category ecosystem materials and model project-based learning (PjBL)integrated STEM can increase student activity in the highly active category [13].

The difference between this research and the previous research lies in the material used, the object, and the research itself. Object in this study is biology with the subject of the respiratory system. Researchers are trying to implement a STEM integrated project-based learning model because it can facilitate and help students to learn breathing system materials and can help them understand the learning materials well including solving questions to deepen the concept of mathematics. In addition, the implementation of stem integrated project-based learning models can improve student learning and student learning outcomes.

Based on the description, the purpose of this study is to find out the effect of STEM integrated project-based learning model on respiratory system material on the activeness and learning results of grade XI IPA students in MAN 1 Jember year 2019/2020.

2. Method

This study applied quasi experimental design research, which is the design of pseudo experiments that have a control group but do not have full control to the outside variables that affect the experiment [14]. with non-equivalent group post-test only design research form. Sampling is carried out using the purposive sampling methodology, which is a method of selecting individuals based on certain criteria. The sample considers academic grades or student learning results from preceding subjects. This study chose two of the five XI natural sciences courses at MAN 1 Jember, Indonesia. Experiment classes are those that get treatment using stem-integrated project-based learning models; in this study, the BIC1 classes were selected as the experiment classes. whereas the control group, BIC class 2, did not receive stem-integrated project-based learning models. BIC 1 has 24 pupils while BIC 2 has 28 pupils. The research was place between January 15th and February 7th, 2020.

The study included a variety of data gathering strategies, including assessments, documentation, and indirect communication in the form of learning activity surveys. The test used in this study was a written test in the form of multiple choice. The post-test administered in both courses after the student's treatment. The research data obtained was checked using normality test first, then analysed by using the Mann Whitney test.

The research instrument used is a post-test and activeness questionnaire. The 20 items of the test that have been validated by three lecturers of IAIN Jember, Indonesia and 1 Biology teacher of Man 1 Jember, Indonesia. The questionnaire of 35 statements has also been validated by three lecturers of IAIN Jember, Indonesia. Instrument trials have also been conducted in XI Natural Science class, MAN 1

Jember, Indonesia, which aims to measure the level of validity, reliability, difference and difficulty level of the instrument. All instrument items both active learning questionnaires and post-test questions have been valid and reliable.

Learning process in control classes was implemented conventionally, which is not using stem integrated project-based learning model but rather using discovery learning model with lecture method. Meanwhile, learning process in the experiment class uses a STEM-integrated project-based learning model.

3. Research Results

The investigated data in this work are presented in the form of study liveliness poll ratings and students' post-test scores.

3.1. Normality Test

The table below summarizes the findings of the normality test for learning activeness and post-test, as well as for the experiment and the control group.

Table 1. Normality of learning activeness questionnaire of experiment and control classes

Data	Class	Probability (p)	Description
Learning Activeness Questionnaire	Experiment	0,029	Not Normal
	Control	0,042	Not Normal

If the p value is larger than 0.05, the data are considered to be regularly distributed. The kolmogorov-smirnov test was employed to determine normality in this investigation, which was conducted using SPSS 26 for Windows. The p-score test for activeness in the experiment class was 0.029, which is less than 0.05, and for the control class was 0.042, which is also less than 0.05. Thus, it may be inferred that data on experiment classes and control classes' learning activeness were not regularly distributed.

Table 2. Normality of learning outcomes data from experiment and control classes

Data	Class	Probability (p)	Description
Post-test	Experiment	0,034	Not Normal
	Control	0,015	Not Normal

We can see from the data that the data for the experiment class were 0,034 which was less than 0.05, and the data for the control class were 0.015 which was also less than 0.05. As a consequence of the post-test findings, it may be determined that the experiment and control classes were not normally distributed.

3.2. Homogeneity Test

After determining the degree of variance between the two groups, namely the experiment and the control group, homogeneity tests were employed to accept or reject the hypothesis by comparing the significant value calculated using Leven statistics to the value achieved. If the significance level is more than 0.05 (sig.> 0.05), then the data is homogenous. The results of the homogeneity test are shown in Table 3 below.

Table 3. Homogeneity of learning activeness and post-test results

Data	F_{count}	Sig	Description
Learning Activeness	9,791	0,037	Not homogeneous
Post-test	18,202	0,019	Not homogeneous

According to the table above, the study's homogeneity test revealed that the Fcount of learning activeness was 9,791 with a significance level of 0.037, while the post-test Fcount was 18,202 with a significant level of 0.019. We may deduce from the data that the difference between learning activity and post-test data is less than 0.05 (sig 0.05), indicating that the data in this research were not homogenous.

3.3. Hypothesis Testing

3.3.1. Student Learning Activeness

After learning the respiratory system, students of the experiment and control classes are given a questionnaire of learning activity. The results of the questionnaire aim to measure the activeness of students' learning in respiratory system materials. The questionnaire was given to the student in the experiment class on February 7th, 2020 and it was given to the control class on February 5th, 2020.

Table 4. Student Learning Activeness Questionnaire Data

Class	Lowest Score	Highest Score	Mean	Standard Deviation
Experiment Class	104,00	137,00	125,71	8,800
Control Class	90,00	134,00	116,11	12,62

According to Table 4, the average active participation of the experiment class is 125.71 with an 8800 standard deviation, whereas the average activeness of the control class is 116.11 with a 12.62 standard deviation; hence, the average active participation of the experimental group is 9.6 more than the control class. The following table compares the experimental and control classes' levels of student learning activity.

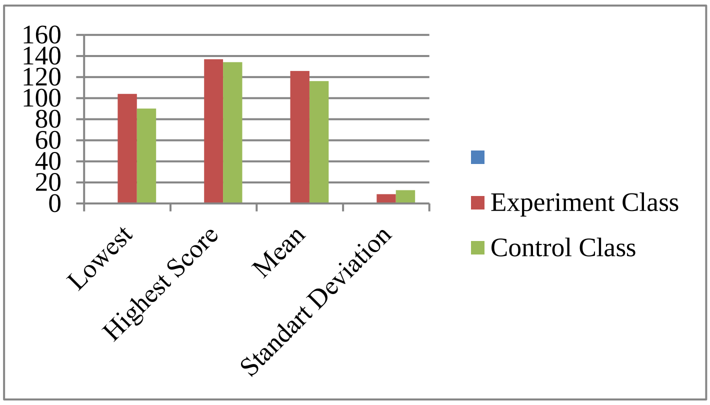

Figure 1. Student Learning Activeness Questionnaire

Furthermore, the average learning activeness score was analysed using the Mann-Whitney U test to test the hypothesis of the difference in learning activeness poll scores averages.

Table 5. Mann Whitney U Test Results on Student Learning Activeness

Class	Average	Mann-Whitney	Z_{table}	Sig.
Experiment Class	125,71	173,500	-2,987	0,003
Control Class	116,11			

From the test Mann-Whitney test calculation, it obtained a result of 173,500 with a significance value of 0.003 and the value of such significance is less than 0.05 ($p = 0.003 < 0.05$). The decision is that H_0 rejected and Ha_a accepted, which means the average score of learning activeness between the control and the experimental class on the respiratory system material differed significantly. It can be concluded that there are significant differences in student learning activeness in experiment and control classes.

3.3.2. Student Learning Outcomes

After studying respiratory system subject, students from the experiment and control classes were given a post-test. The purpose of the post-test is to assess students' learning outcomes in the respiratory system course. On February 7th, 2020, the experiment class received a post-test, whereas the control class received one on February 5th, 2020. 140 minutes is allotted for post-testing.

Table 6. Student Learning Outcomes Data

Class	Lowest Score	Highest Score	Mean	Standard Deviation
Experiment Class	65,00	95,00	85,42	6,90
Control Class	60,00	90,00	75,36	9,61

According to the data, the average Learning Outcomes score for experiment courses was 85.42 with a standard deviation of 6.90, while the average for control courses was 75.36 with a standard deviation of 9.61. Thus, the average results of the experiment class were 10.06 points higher than those of the control class. The graphical description of student's learning outcomes between the experiment and the control class can be seen in figure 2 below.

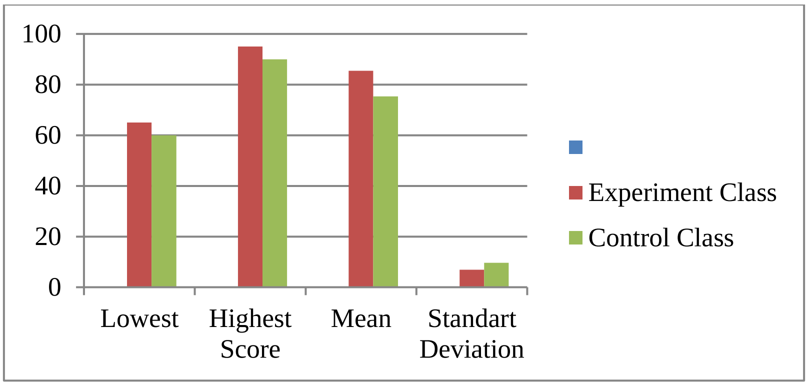

Figure 2. Student Learning Outcomes

Furthermore, the average post test score was analysed using Mann- Whitney U to test the hypothesis of the difference in average student learning outcomes.

Table 7. Mann Whitney U Test Results on Student Learning Outcomes

Class	Average	Mann-Whitney U	Z_{table}	Sig.
Experiment Class	85,42	137,000	-3,713	0,000
Control Class	75,36			

From the results of the mann-whiteny U test showed above, the result was 137,000 with a significance value of 0.000 or less than 0.05 ($p = 0.000 < 0.05$). The conclusion was that H_0 rejected and H_a accepted, which means that the average post-test between experiment and control class on respiratory system subject differ significantly. It can be concluded that there are significant differences in students' learning outcomes between experiment and control classes.

4. Discussion

According to the data analysis findings, the average score for student learning activeness in experiment courses where STEM integrated project-based learning is used was 125.71. Meanwhile, the control class's average score was 116.11. The average score for student activity in the experiment class is higher than the average score for student activity in the control class. Along with the average difference in the average score of the activeness poll between the experiment and control classes, the Mann-Whitney test may be used to explain the discrepancy.

The data obtained show that the average post-test score of the experiment class students was 85.42, while the average post-test score of the control class students was 75.36. The post-test grades of the experiment class students were greater than the control class. In addition to using the average difference in learning outcomes in experiment classes and control classes, it can also be explained by the Mann-Whitney test.

Prior to the treatment, there are no noticeable difference of learning activeness and learning outcomes between experiment classes and control classes. However, having been treated by applying a STEM-integrated project-based learning model to the experiment class, it showed significant differences in learning activeness and learning outcomes, based on the average score of the student activeness questionnaire and the learning outcomes of the experimental and control class, students. This demonstrate that the treatment of STEM integrated project-based learning models influencing students' learning activeness and learning outcomes.

The behaviour changes and improvement due to learning experience are referred to as learning outcomes. In this case, the learning outcomes are obtained if a person has experienced a learning process [15]. Learning is a stage of change throughout the behaviour of an individual as a result of experience and interaction with the environment involving cognitive processes [16]. STEM classroom learning may increase the quality of the learning process and the results. Learning results may differ in a number of categories, including academic learning, attitude, motivation and high level thinking capabilities. On the basis of various research, the learning process and results might vary in numerous parameters, such as topics, length of learning or even environmental variables [17]. Project based learning integrated with STEM requires cooperation, communication between partners, problem solving, as well as self-management. STEM project-based learning help students in bridging between knowledge learned in school and the real world. The integration between several fields of science in STEM project-based learning helps students provide the knowledge that one field of science is closely related to other fields of science [18].

The change applied provides a good influence for students understanding of the concept, proven by the increasing of the post-test and questionnaire result which means that there is learning process. Where the average test score of the test class is greater than the average control class score used for traditional learning. This improvement is due to the STEM integrated project-based learning approach that is used in the experimental class to apply project work in the learning process in order to provide the students with a knowledge of ideas.

The findings of this study corroborate those of Nadia Putri's previous study, which found that students are interested in stem integrated project-based learning models in a majority (76 percent) and that students are more active in completing projects to solve problems and discover concepts, as evidenced by the results of the student response questionnaire, which indicated that 80 percent of students are active in completing projects to solve problems and discover concepts.

The results of this study also support the research conducted by Fury et al. The results showed that the classes learned by STEM integrated based learning projects had a greater value of 97% compared to the project-based learning class which had a value of 84%. Learning using STEM integrated project-based learning can improve the cognitive learning aspects, which is seen from higher *N-gain* scores compared to the use of project-based learning model [10].

The findings of this research corroborate those of Lutfi et al., who demonstrated a difference between the experiment and control groups. These visible differences are found in pre-test and post-test. The predicted scores between the two classes showed that the early learning scores of the learners between the classes were not much different, even the initial score of the control class was higher than the experiment class. After being given the treatment, the difference in the average post-test score from experiment class compared to the control class were noticeable. The average test scores were 95.54 for the experiment class and 83.22 for the control class. The discrepancy shows that the difference in treatment with the application of STEM integrated project-based learning models is affecting the students learning outcomes [11].

5. Conclusion and Suggestion

On the basis of the hypothesis for both the proposed research concerns, as well as the results of analysis. in this research, it is possible to conclude that there have been differences in the learning active participation of learners who have used stem integrated project-based learning models versus those who have not. As shown by the difference in average scores on surveys evaluating learning activities between both the experiment and control classes. Additionally, there are significant differences in the outcomes of student learning when stem-integrated project-based learning methodologies are employed vs when they are not employed. This reveals that the STEM incorporated project-based literature showed has a significant impact on the learning activities and outcomes of students in grade XI Natural Sciences at MAN 1 Jember, Indonesia. This study mainly examines students' cognitive learning outcomes, it is advised that future research examine students' affective and psychomotor learning outcomes across subjects, particularly in biology learning. Additionally, it is advised that deeper analysis study the influence of integrating project-based learning with STEM on several key 21st century skills that student should possess.

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