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Revitalizing Creativity: Enhancing Students' Creative Thinking through STEAM and Project-Based Learning in Human Respiration Studies

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One of the skills that students need to face global competition is the ability to think creatively. This study aims to determine the effect of applying the STEAM approach with the Project-Based Learning (PjBL) model on improving students' creative thinking skills on human respiratory system material in primary schools. The type of quantitative research used is experimental research. The type of experimental research employed is quasi-experimental with a non-equivalent control group design. The data analysis techniques used in this study were normality test, homogeneity test, and hypothesis testing using independent samples t-test. The research results from hypothesis testing using the Independent Samples t-test show that the Sig. (2-tailed) value is 0.000, indicating that H0 is rejected and H1 is accepted. Thus, because the value of Sig. (2-tailed) obtained is less than 0.05, it can be concluded that there is an effect of STEAM using the Project-Based Learning model on the creative thinking skills of students in Class V Human Respiratory System Science Material at SDN 011 Kota Samarinda. The increase in the creative thinking skills of the students in the experimental group was 0.42 and was placed in the medium category. In conclusion, the application of the STEAM approach combined with the Project-Based Learning model significantly enhances the creative thinking skills of primary school students in the context of human respiratory system material.

1. Introduction

In the 21st century, education is becoming increasingly important in training the next generation with learning and innovation skills, using technology and information media, creative thinking, and survival skills. The role of technology in learning today is significant in facilitating educators in managing and designing creative and innovative learning according to school conditions and students' needs. Especially at the elementary school level, elementary school students have learning characteristics with interactive things that can make students actively involved in the learning process (Suhartini & Haerani, 2023). Students must have 6 C skills (Critical thinking, Collaboration, Communication, Creativity, Character, and Citizenship) (Hastuti, 2022). One of the skills that needs to be developed in the 21st century is creativity. Creative thinking skills are essential for each individual to have as a way to help students solve problems in the future (Susanto et al, 2015). This aligns with 21st-century education, emphasizing a student-centered learning process so that teaching and learning activities are more innovative and creative.

Creative thinking skills are essential for each individual to have as a way to help students solve problems in the future. By thinking creatively, someone can produce new knowledge to solve a problem (Revenko et al., 2024). Rahayu et al. (2019) explain that Indonesia's ability to think creatively is still low; this fact can be confirmed by the results of the Global Creativity Index in 2015 Indonesia is ranked 115 out of 139 countries (Richard, 2015). This shows that the ability to think creatively in Indonesia is still low, so it is necessary to train creative thinking skills, especially for students. The low level of students' creative thinking skills is because teachers do not train students in creative thinking skills. This is because the learning process tends to memorize rather than understand concepts. After all, the language given tends to be the same as in the book (Qomariyah & Subekti, 2021).

Based on the observations made by researchers in class V SDN 011 Samarinda Kota, researchers saw the learning process, especially in science learning. Researchers found that the learning activities were still less varied and less interesting. The activities carried out are still too passive, so the process of stimulating children's creativity does not appear. Teachers are less creative in applying learning models, and the media cannot stimulate children's creative thinking skills. There are no activities that can give children the opportunity to explore, imagine, and experiment to develop their ideas. So, students cannot find ideas to solve problems.

In essence, applied science learning should involve practical activities so that students can directly feel and apply the concepts, which can enable students to develop creative thinking skills. Yandhari et al. (2019) identified the characteristics of creative thinking skills through flexibility, fluency, elaboration, and originality. Therefore, hands-on practice in science learning is the key to stimulating students' creative thinking skills. The problem of students' low creative thinking skills requires approaches and models that harmonize with students' characteristics and needs. One of the reasons why students have difficulty understanding scientific problems is the lack of student involvement in learning activities. A plan considering students' needs and preferences is needed to create a more interesting and relevant learning environment. This will improve teaching standards and students' understanding of the subject (Rasidah et al., 2022).

Selecting a learning model tailored to the problems in the field is very important in improving students' creative thinking skills (Wulandari, 2019). Students' creative thinking skills will not be improved if the learning process is only teacher-centered (Syarifuddin et al., 2022). One solution that can be used to overcome the problems is to use an approach with an innovative learning model that can create an active and enjoyable learning atmosphere to help students understand complex subject matter and improve students' creative thinking skills (Suciati et al., 2024; Yasifa et al., 2023). One approach with an innovative learning model is the STEAM approach with the Project-Based Learning (PBL) model.

STEAM is a modern approach that integrates learning concepts that focus on aspects of collaboration to develop students' ability to solve problems that arise in 21st-century life (Yasifa et al., 2023). STEAM learning is a learning model that combines five disciplines, namely science, technology, engineering, arts, and mathematics, to solve problems that occur in real life. The STEAM approach can provide students with projects during learning (Triprani et al., 2023). This is consistent with the principles of project-based learning (PjBL) learning paradigm, which can produce outputs in the form of products, making the project a focal point in implementing learning (Nugroho & Dewi, 2022; Triprani et al., 2023).

The PjBL learning model encourages students to solve contextual problems through complex activities such as research, collaborative project implementation, product manufacturing, and product development. In addition, students can investigate a topic based on real-world problems in groups and seek knowledge from multiple sources (Muyassaroh et al., 2022). Implementing PjBL through the STEAM approach supports science learning that focuses on mastering concepts and developing the ability to think and solve problems, investigate, and collaborate (Muyassaroh et al., 2022). Applying the STEAM-PjBL learning process can provide opportunities for students to think creatively and logically by generating ideas and solutions to a problem through hands-on activities (Triprani et al., 2023). This research highlights the importance of learning that connects academic concepts to real-world problems. The PjBL-STEAM approach can help students develop 21st-century skills in high demand in the workforce, such as critical thinking, creative, collaborative, and problem-solving skills. This research is urgent because it is relevant to current educational issues, namely, how to prepare students for the challenges of the 21st century. This research can make a significant contribution to the field of science education by using a quantitative approach to explore the implementation of the STEAM-integrated Project-Based Learning (PjBL) learning model. Through an in-depth case study, this research will reveal the dynamics of student learning as they complete STEAM-based projects and identify factors that influence the successful implementation of this learning model. The results of this study are expected to provide relevant implications for curriculum development and learning practices in schools.

2. Method

The research method used is quantitative, with the type of research used being a quasi-experiment or pseudo-experiment, with a research design of a nonequivalent control group design. The population in this study was fifth-grade students of SDN 011 Samarinda Kota, consisting of 85 students divided into four classes (classes V A to V D). Sampling in this study was done using a purposive sampling technique. The samples taken for this study were class V, an experimental class with 19 students, and class V, a control class with 21 students.

The data collection techniques used in this study were observation, interviews, and tests. According to the techniques, this research instrument includes observation sheets, interview sheets, and test questions. The test instrument consists of 10 descriptive questions that lead to indicators of creative thinking ability, so it can provide an overview of students' ability to express solutions in the context of the problem. The research data analysis technique uses normality, homogeneity, and hypothesis testing, using the independent sample t-test, with the basis for decision making when H_1 is accepted and H_0 is rejected if $t_{count} > t_{table}$, using a significance level of 5% = 0.05. The category of n-gain score is shown in Table 1.

Table 1. N-Gain score categories

N-Gain Value	Category
$g > 0.7$	High
$0.3 < g < 0.7$	Medium
$g < 0.3$	Low

Source: (Dzahabiyah dkk., 2021)

3. Result and Discussion

This research was conducted in Class V Negeri 011 Samarinda Kota with a total sample of 40 people. This sample is divided into two classes: V B, with as many as 19 people, and V C, with as many as 21 people. The primary data used as research material for this school was taken from the pretest and posttest results. Pretest and posttest were given science content material, namely the human respiratory system. Before this pretest and posttest were given, the researcher had tested the feasibility of learning instruments. The tests that were conducted were validity test, reliability test, difficulty test, and question differentiation test.

The validity test in this study was used to validate the student's creative thinking skills essay test instrument with 10 pretest and posttest questions. The instrument validity test technique in this study used the product-moment correlation. Based on the validity test results, 10 questions met the criteria, so they were said to be valid. In the reliability test, the Cronbach's alpha value of the essay question reached 0.780, which indicates that the reliability of the essay test instrument meets high standards. In addition to the validity and reliability tests, the researchers also tested the questions' difficulty level and discriminative power. In the test of the difficulty level of essay items, three items fell into the easy category, and seven fell into the sufficient category. Meanwhile, the test of the discriminating power of essay items showed that eight were in the good category and two in the sufficient category.

An overview to determine the acquisition of creative thinking levels of students before and after learning can be obtained from the increase in pretest scores to posttest scores in both experimental and control classes. The data on pretest and posttest scores in experimental and control classes is shown in Figure 1 below.

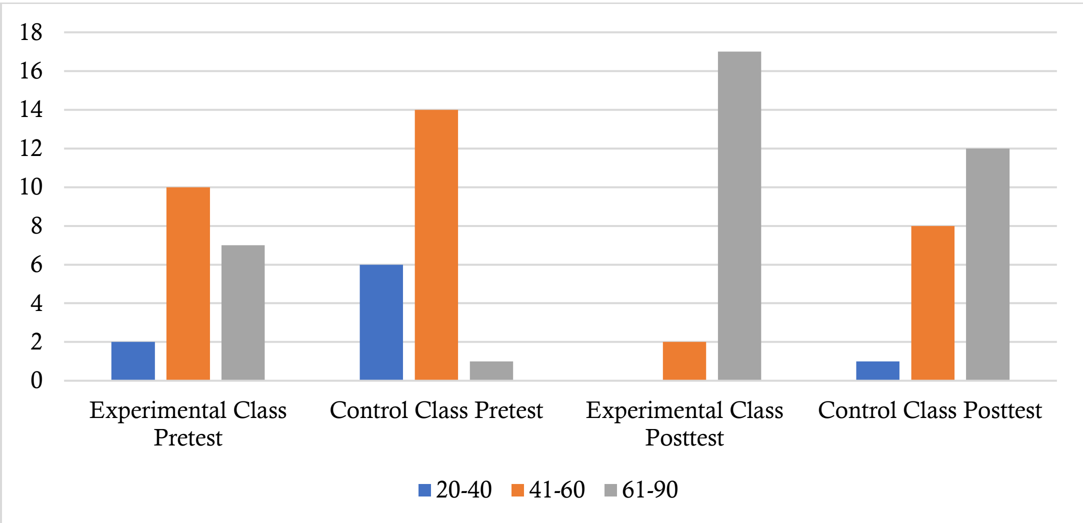

Figure 1. Graph of pretest and posttest scores for experimental and control classes

Based on the graph above, it can be seen that the students' ability to solve questions about the human respiratory system material is high. This is evidenced by the final scores of students who are dominant in the 61-90 interval, which means that students can answer some of the given questions correctly. In the experimental class, two students got pretest scores in the 20-40 interval, while in the control class, there were six students. There were 10 students in the experimental class who scored in the 41-60 range, while 14 students were in the control class. For the pretest score interval of 61-90 in the experimental class, there were 17 people, while in the control class, there were 12 people. In this pretest, the experimental class was superior to the control class with an average experimental class score of 56.58 and an average control class score of 46.29.

In the posttest, it can be seen that there is a striking difference between the posttest scores of the experimental class and the control class. This is evidenced by the increase in the number of students scoring in the 61-90 range. This means they can better answer scientific questions about the human respiratory system. From these data, one student from the control class obtained a posttest score in the 20-40 interval, while no students from the experimental class obtained a posttest score in the 20-40 interval. Then, in the 41-60 interval, there were two students from the experimental class and eight from the control class. While in the 61-90 interval, there were 17 students from the experimental class and 12 from the control class. In the results of this posttest, the experimental class was superior to the control class, with the average score of the experimental class being 75.53 and the average score of the control class being 61.81.

The normality test used in this study is the Shapiro-Wilk test, where if the significance value > 0.05, then the data is normally distributed. If the significance value <0.05, the data is not normally distributed. Based on the results of the pretest and posttest scores of the experimental and control classes tested using SPSS, the following data are shown in Table 2.

Table 2. Normality test results for experimental and control classes

	Pretest		**Posttest**	
	Control Group	**Experiment Group**	**Control Group**	**Experiment Group**
Sig.	0.094	0.308	0.058	0.208
Shapiro-Wilk	Sig. > 0.05, the data is considered normal.			

Based on the table of normality test results above, it can be seen that the pretest and posttest data of the experimental class are normally distributed, as evidenced by the significance value > 0.05. As for the control class, the pretest and posttest data were declared to be normally distributed. This is evidenced by the significance value > 0.05. Since some data meet the criteria, the pretest and posttest normality test results for the control class and the experimental class are declared normally distributed.

The homogeneity test used in this study is the Levene test, where if the significance value is > 0.05, then the data is homogeneous. If the significance value <0.05, then the data is not homogeneous. Based on the results of the post-test scores of the experimental class and the control class, the following data were obtained:

Table 3. Homogeneity test results for experimental and control classes

	Pretest and Posttest
Sig.	0,688
Levene's Test	Sig. $\geq$ 0,05 then H_0 is accepted
Decision	Homogeneous data

Based on Table 3 of the homogeneity test results above, it can be seen that the data of pretest and posttest results of the experimental class and control class are homogeneous. This is evidenced by the significance value > 0.05. Since the data meet the criteria, the homogeneity test results of the pretest and posttest of the control class and the experimental class are declared homogeneous.

After conducting a normality test and a homogeneity test, the next step is to test the hypothesis or preliminary assumption that has been made. Since the data in the results of this study were normally distributed and homogeneous, the hypothesis test was performed using the parametric test, namely the Independent Samples T-test. The following data were obtained based on the post-test scores of the experimental and control classes shown in Table 4.

Table 4. Hypothesis test results

	Independent Sample t-test
Sig. (2-tailed)	0,000
	sig. ≤ (0.05)
Decision	H_0 rejected

Table 5 shows that the post-test data has Sig. (2-tailed) which is smaller than 0.05, which is 0.000, then H_0 is rejected, which means there is a significant average difference between the creative thinking skills of the experimental and control groups.

In this study, the n-gain score test was used when there was a significant difference between the experimental group's average posttest score and the control group's posttest score through the independent samples t-test.

The increase in creative thinking skills in the experimental and control groups can be seen by finding the n-gain scores. The average n-gain in both groups can be seen in Table 5.

Table 5. Average n-gain results

	Control Group	Experiment Group
N-gain	0.27	0.42
Description	Low	Medium

The results of the n-gain score test calculation show that the average value (mean) n-gain score for the experimental class is 0.42, which is in the medium category. The n-gain score test calculation results show that the average value (mean) n-gain for the control class is 0.27 in the low category.

Creative thinking ability consists of several aspects, including fluency, flexibility, originality, and elaboration. The improvement in the ability of each aspect can be known by finding the n-gain score of each aspect. The n-gain results for each aspect are shown in Table 6.

Table 6. Average results of the n-gain by aspect

Creative Thinking Aspects	Control Group		Experiment Group	
	N-Gain	Description	N-Gain	Description
Fluency	0.15	Low	0.56	Medium
Flexibility	0.37	Medium	0.46	Medium
Originality	0.14	Low	0.36	Medium
Elaboration	0.24	Low	0.29	Low

Table 6. shows the average n-gain scores for each aspect of creative thinking ability. In the control class, the n-gain score was in the moderate and creative category. The highest score was in the flexibility aspect with a score of 0.37, while the lowest n-gain score was in the originality aspect with a score of 0.14. In the Experiment class, the n-gain scores in the Flexibility, Originality, and Fluency aspects were in the medium category. At the same time, the Elaboration aspect is in the low category. The highest score is in the Fluency aspect with a score of 0.56. The lowest n-gain score in the experimental class was in the Elaboration aspect, which was 0.29.

The learning activities in the experimental class were carried out by applying the STEAM-based Project-Based Learning learning model. STEAM is a modern approach that integrates learning concepts that focus on aspects of collaboration to develop students' ability to solve problems that arise in 21st-century life (Yasifa et al., 2023). The STEAM approach can provide students with projects during learning (Triprani et al., 2023). This aligns with the principle of the Project-Based Learning (PBL) learning paradigm, which can produce output in the form of products, thus making the project a focal point in implementing learning (Triprani et al., 2023). PjBL through the STEAM approach supports science learning that focuses on mastering concepts and developing the ability to think and solve problems, investigate, and collaborate (Muyassaroh et al., 2022). Applying the STEAM-PjBL learning process can provide opportunities for students to think creatively and logically by generating ideas and solutions to a problem through hands-on activities (Triprani et al., 2023).

The first learning session in the experimental class was held on May 16, 2024. At this stage, students are allowed to understand the material through STEAM-based PjBL learning conducted by the teacher and discuss the material to be given, namely the human respiratory system. In addition, the second learning session was held on May 18, 2024. In this lesson, students learn about the material on how to maintain the health of the respiratory organs through STEAM-based PjBL learning conducted by the teacher. The syntax and steps of the project-based learning model through the STEAM approach in this study, according to Laboy Rush 2010, (Muyassaroh et al., 2022), in Figure 2.

Figure 2. Syntax of the PjBL-STEAM Model

The steps of teaching and learning activities in this experimental class are certainly very different from the conventional learning in the control class. The learning in the control class only focuses on the continuous delivery of material, then continues with doing tasks and discussing them together. In this conventional learning, the researcher only ensures that the results obtained by the students in solving the problem of the human respiratory system material are correct.

The difference between the average pre-test and post-test scores of the experimental and control classes is evident when comparing the average scores of the experimental and control classes. The average post-test score of the experimental class was 75.53, with an initial ability (pre-test) of 56.58. On the other hand, the average post-test score of the control class was only 61.81, with a pre-test score of 46.29. From this, it can be seen that the difference in post-test scores between the experimental and control classes is quite significant. Both research classes have the same interest and enthusiasm for learning science. Pupils who follow the learning process are based on feelings of enjoyment, where pupils carry out their experiments given by the teacher, observe the experimental process, and write down the experimental results. Researchers chose this method because if students learn through direct experience, the meaning of learning will be more visible, and students' creative thinking level will appear more (Permatasari, 2023).

Tembrevilla et al. (2024) stated that through direct experiments or experimental learning, students' curiosity will be increased, and students will become rich in knowledge and experience. Suppose the knowledge and experience can remain in the students' memory for a long time. In that case, the students have understood the meaning of the learning material provided by the teacher. Thus, direct experimentation or experiential learning can improve students' creative thinking skills. In addition, this study's results align with relevant research conducted by Fitriyani et al. (2024), which suggests that there is an effect of the STEAM-based project-based learning model on students' creative thinking skills. Although there are some differences, such as materials, research subjects, and data analysis techniques used, the results obtained are similar to the results of this study.

The learning model is effective if the Gain Score value is > 0.3 or at least in the moderate category (Dewi et al., 2022). The Gain Score value obtained in the experimental class is 0.42, which is in the moderate category. The moderate category of N-gain indicates that the learning model can potentially improve student learning outcomes (Dewi et al., 2022; Lavado-Anguera et al., 2024). However, other factors need to be considered when assessing the effectiveness of a learning model. Based on the results of the N-gain score, it can be concluded that the project-based learning model is effective for use in science subjects. The increase in students' creative thinking skills can also be seen from the n-gain score per aspect in the experimental class.

The n-gain score for the fluency aspect in the experimental group is 0.56 and is in the medium category. This increase can occur because this aspect is trained in the students during the learning process, specifically in the reflection and communication learning steps. In these two learning steps, students must be able to express their thoughts or ideas fluently. Fluency is a person's ability to express ideas smoothly (Ulfa & Asriana, 2018). The next aspect of creative thinking is flexibility. The n-gain score obtained in this aspect is 0.46 (moderate category). The flexibility aspect is taught to students during the discovery and application learning steps. In this step, students are asked to think of solutions to a problem and then realize the solution. Flexibility is obtaining different approaches, building various ideas, and taking paths (Nugroho et al., 2019).

The third aspect is originality with an n-gain of 0.36 (medium category). The increase occurred because, during the discovery learning step, students are required to be able to come up with ideas or solutions to problems by creating new ideas. Originality is the ability to create an innovation others have not considered (Ulfa & Asriana, 2018; Wahyudi et al., 2024).

Furthermore, the last aspect of creative thinking ability is elaboration with an n-gain score of 0.29 (low category). This aspect is trained in students during the communication learning step. Although it is important to explain factors that add details to ideas so that they become more meaningful, the evaluation results show no significant improvement in students' ability in this aspect. In this step, students are asked to participate actively in question-and-answer sessions and make suggestions between groups. This activity aimed to develop elaboration skills by encouraging students to explain their ideas in more detail.

The research data analysis shows that the positive results of implementing the project-based learning model are improving creative thinking skills. The gain score value of the three aspects of creative thinking (fluency, flexibility, originality) significantly increased after implementing project-based learning. The project-based learning model successfully stimulates students to think more creatively in solving problems (Siswanto et al., 2023). STEAM (Science, Technology, Engineering, Arts, and Mathematics) combined with Project-Based Learning (PjBL) has been proven effective in improving students' creative thinking skills. This learning model encourages students to actively participate in the learning process through real projects requiring critical and innovative thinking. For example, research by Muzaini et al. (2024) shows that integrating STEAM with PjBL can improve elementary school students' creative and collaborative thinking skills. In addition, Papilaya and Salhuteru (2024) found that STEAM project-based learning focused on "Sound of Green" successfully empowered students to think creatively. Kuo (2024) also emphasized that the practical synthesis between STEAM and PjBL empowered students to think creatively. Hamid et al. (2024) added that STEAM-based LKPD-PjBL on acid-base solution material can improve students' creative thinking skills. All of these studies emphasize that the STEAM-PjBL approach facilitates in-depth learning and empowers students to develop innovative and solution-oriented ideas.

4. Conclusion

Based on the results of this study, it is concluded that STEAM learning with the PJBL (Project-Based Learning) model is effective in achieving students' creative thinking skills in class V human respiratory material. This is shown from the hypothesis testing using the independent t-test, which shows that the significance value is less than 0.05, namely Sig. (0.000) <0.05, so H0 is rejected, then H1 is accepted. Thus, it can be concluded that there is an effect of the STEAM-based Project-Based Learning model on the material of the human respiratory system on the creative thinking skills of grade V students of SDN 011 Samarinda Kota in the learning year 2023/2024. The PjBL-STEAM learning model is proven to improve students' creative thinking skills in the experimental group with an n-gain of 0.42, which is in the medium category.

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