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Creative Thinking and Collaborative Ability of Elementary Students with the Implementation of the STEM Integrated Project-Based Learning Model

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ABSTRACT

This paper is motivated by the author's efforts to improve the quality of Human Resources (HR) in accordance with the demands/developments of the times. This research was conducted to (1) find out how the differences in creative and collaborative thinking skills through STEM-integrated project-based learning and the use of conventional learning models, (2) describe creative and collaborative thinking skills using STEM-integrated project-based learning models. This study uses a quantitative approach method. It was held at Gugus 4 Cibadak, Public Elementary School Pamuruyan (as the control class) and Public Elementary School Cilengo (as the experimental class). Creative thinking data collection is using posttest and pretest, while for collaborative ability data collection is by observation sheets. The results showed that (1) the creative thinking ability (mean pretest 32,14 for experiment class and 40,17 for control class, mean posttest 79, 29 for experiment class and 40,83 for control class) and collaborative ability of the class with STEM-integrated project-based learning were superior/got more significant results than the class that used conventional learning models, (2) students' creative abilities emerged into several indicators such as fluency, flexibility, original thinking, and elaborative thinking, (3) collaborative abilities appear in the field based on indicators of confidence, positive attitude, respect, giving encouragement, and building group spirit.

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1. INTRODUCTION

Education is a very important factor in improving the quality of life. If viewed from its implementation, education in the implementation of learning prepares individuals to have broad insight, critical thinking, creative thinking to solve and provide solutions to a problem (Wardani et al., 2021). This is in accordance with the Regulation of the Minister of National Education No. 54 of 2013 concerning graduate competence standard for Primary and Secondary Education in lesson plan are cognitive, affective and psychomotor. Based on this, it can be said that with education, any conditions to be achieved in the future can be designed and pursued with the activities carried out.

The 2013 curriculum aims to make students have better ablility to do activities namely asking questions, reasoning, observing and communicating after receiving learning materials from the teacher. The implementation of the 2013 curriculum is implemented through an integrative thematic-based learning program, scientific approach activities. The 2013 curriculum emphasizes student competence (student centered) including creativity (Nahar et al., 2022).

In accordance with the times and technological advances, problems in education are increasingly complex, Human Resources (HR) must be able to think creatively. Creative thinking includes thinking skills that involve processes that create new things. Students should be given the opportunity to develop creativity by working as much as possible in the learning process.

The ability to think creatively is one of the higher-order thinking skills (Wardani et al., 2021). The ability to think creatively cannot be achieved if learning activities do not involve students actively in understanding concept formation, do not use creative learning methods and teaching and learning activities and always teacher-centered.

The problem that occurs is related to creative thinking must have an effort that students do not only listen and memorize in the learning process, but also students must be able to solve problems. When learning is conditioned to solve problems, it will train students to connect the concepts they have with real life, students must be able to develop thinking skills to solve the problems they face.

In addition to being related to the 2013 curriculum in implementing 21st century learning, problems that often arise are when implementing thematic learning. Some students find thematic learning difficult to understand because the theme-based learning system contains several subjects in one lesson. Too much material makes students often have difficulty, and get bored when participating in classroom learning so that students' thinking skills are very weak, less creative and the information obtained is not related to everyday life.

Another obstacle in learning is influenced by teachers who do not involve students to play an active role in learning activities. The teacher only uses the lecture method, does not use varied methods and learning media to help the learning process. Another problem that arises during learning is that the learning atmosphere is not conducive. This interferes with the concentration of other students which ultimately affects thinking skills and expected learning outcomes. One of the discrepancies that occur when problems arise in learning can be seen from students' scores that are below from the standard of Minimum Completeness Criteria (KKM).

Problems accompanied by the fact that grades achieved are below from the standard were found from observations made by researchers at elementary school Cilengo and elementary School 9 Pamuruyan, Cibadak District, Sukabumi Regency, especially in grade 4.

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The results showed the low ability of students to develop their potential. Most students still have difficulty in thinking creatively to solve the problems given and still having difficulty in communicating ideas both individually or the results of group discussions. Another problem that arises is the low ability to work in groups or collaboratively. Some students in group discussions or assignments just wait for answers and do not contribute thoughts, ideas or other contributions, students only focus on one answer, and they are not challenged to think of various alternative answers. They keep asking what to do when the teacher gives instructions in detail, they also find it difficult to provide new and original ideas, and answer questions with concise answers (sparing), and do not try to provide answers that are broader and satisfying. Collaborative ability is considered a successful interaction in the classroom with evidence of learning achievement (Indrawan, 2021).

Other problems also arise when implementing learning in the classroom. It can be seen during the learning process that students often have difficulty in solving problems or more complex problems. This is because the learning process seems boring so that students are less active and some do not pay attention to the teacher's explanation. The results of interviews with fourth grade students in two schools namely State Elementary School Cilengo and State Elementary School 9 Pamuruyan showed that students rarely asked questions if there was material that they did not understand the explanation. Students only answer questions or problems according to the examples that have been given, and do not try to find alternative answers.

The problems that found during the classroom learning must focus on the applicable curriculum, namely the 2013 curriculum (in the 2013 curriculum it is clearly explained that achieving learning goals can make students think creatively). Creative thinking is needed to solve complex problems. By developing students' abilities in the creative thinking aspect, they will be able to solve a problem in various ways. Through the creative thinking process, students are emphasized to experience, master and solve the problems they face. The existence of creativity in learning process is expected to stimulate students to have the courage to solve a problem in their own way.

As for the learning model that can be applied according to the criteria for creative and collaborative thinking, one of the suggested learning models in implementing the 2013 curriculum is Project Based Learning or PBL. The application of PBL is an effort to increase collaboration capabilities (Hambali et al., 2020). PBL requires creative and critical thinking from students (Goyal et al., 2022).

PBL integrates knowledge and improves skills (Gomez-del et al., 2022). PBL enables students not only to develop their intellectual skills but also their manual skills. PBL is a learning model that emphasizes student experience by giving time and opportunities for students both individually and in groups to be able to solve problems given related to the material and then in accordance with environmental conditions to be able to increase student creativity, it helps students find new ideas, make and create a work/product based on theoretical concepts/information obtained (Natty, 2019).

Project-based learning is an innovative learning model, with project-based learning students with the help of the teacher not only collect information but they also have to use their thinking and reasoning skills to understand the information. PBL applies knowledge based on experience with integrated and detailed systems (Beuchat et al., 2022).

PBL focuses on student activities in the form of gathering information and utilizing this information to produce something useful for students' lives/for others, all activities carried out by students will be based on Core Competencies or Kompetensi Inti (KI) and Basic Competencies or Kompetensi Dasar (KD) in the curriculum (Nurhadiyanti et al., 2021).

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Related to the experience during teaching and during observations in both schools, problems were found in the learning situation, namely the individualistic nature of students that was often seen. Students tend to be individually competent, being closed to friends, wanting to win on their own, paying less attention to classmates and even students who don't know some of their classmates because these students only hang out with certain groups without ignoring other friends and so on. When the problem is considered normal, it will produce graduates who are selfish, cannot get along with friends, are indifferent to society and the environment, cannot respect others, and do not want to accept the advantages or disadvantages of others. Therefore, with the application of the PBL model, it is hoped that it will help students to socialize with others by learning together or in groups through a project and producing a work in learning.

In addition, besides project-based learning, the teaching and learning process must also keep up with the times, in the current era of globalization, everything is related to the nuances of Science, Technology, Engineering, and Mathematics (STEM). STEM focuses on finding and increasing interest and motivation in learning (McIntyre et al., 2021).

STEM is faced with challenges that are aligned with student behavior in the implementation of learning (Mutambara and Bayaga, 2020). The STEM approach in learning is expected to produce meaningful learning and be able to apply it in everyday life. STEM learning is not only related to theory, but also practice as an effort for students to experience the learning process directly. STEM learning is a collaboration of the four fields of science that are compatible with problems that occur in the real world (Fathoni et al., 2020). Science is considered as systematic knowledge that is obtained by carrying out observations. Technology is a whole tool which purpose is to meet human needs in survival. Technique is an approach in implementing something. Mathematics is a science related to numbers, the relationship between numbers, operational procedures used in tackling problems related to numbers. STEM allows students to explore how things work and why things happen (Zucker et al., 2021).

2. METHODS

This study uses a quantitative approach with a quasi-experimental design type. The pattern of the implementation of the research is the pretest and posttest control group design. The research subjects of the experimental class were the 4th grade students of State Elementary School Cilengo, totaling 28 people. As for the control class, there are students at State Elementary School 9 Pamuruyan with a total of 30 students. The experimental class was treated with the application of an integrated STEM project-based learning model. The control class was treated with the application of conventional learning models. The instrument in this study was a learning device consisting of a syllabus, lesson plans, student worksheet, and data collection instruments in the form of pretest and posttest questions (used to determine students' initial and final abilities in creative thinking skills). To get data on collaborative abilities, student observation sheets were used.

3. RESULTS AND DISCUSSION

Data on the ability to think creatively is obtained by testing creative thinking, while collaborative abilities are obtained by non-testing. Both are analyzed. The indicators of creative thinking are (1) fluid thinking, (2) flexible thinking, (3) original thinking, and (4)

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elaborative thinking. Meanwhile, indicators of collaborative ability are (1) self-confidence, (2) positive attitude, (3) respect, (4) giving encouragement, (5) building group spirit.

Data were obtained from the results of the test instrument in the form of essay questions to determine students' creative and collaborative thinking skills after using the STEM integrated project-based learning model (in the experiment class) and observation sheets to determine students' creative and collaborative thinking skills after learning with conventional methods (in the control classroom). **Table 4.1** discusses the Recapitulation of Creative Thinking Ability Test Scores.

Table 4.1 Recapitulation of Creative Thinking Ability Test Score

Score	Experiment Class		Control Class	
	Pretest	Postest	Pretest	Postest
Highest	55	100	65	70
Lowest	15	30	15	10
Average	32.14	79.29	40.17	40.83

Based on the **Table 4.1**, it can be seen that the highest score for the controlled class pretest is 65 compared to the experiment class 55, while the experiment class posttest has a greater value of 100 compared to the control class posttest. For the lowest pretest value, the experiment class and the control class have the same value, namely 15. Furthermore, for the pretest the average value of the control class is 40.1 greater than the experiment group of 32.1, and the posttest average value of the experiment class is 79.2 greater than the control class, namely 40.83.

Based on the research, the results obtained regarding collaborative abilities were there was an increase in the experimental and control classes. Where the increase in the experimental class was more significant than the increase in the control class (it can be seen in the attachment to the value of the collaborative abilities of the experimental class and the control class). Based on the collaborative ability observation sheet, it was found that most of the students' collaborative abilities were at a very good level.

With regard to collaborative abilities, based on research, certain indicators appear namely (1) self-confidence (including attitudes of students, namely willingness and effort, optimistic and independent attitudes), (2) positive attitudes (including statements with positive attitudes towards other people related to abilities as well as the expected roles, discussing group members positively, and appreciating the results of the work obtained by the group, and playing an active role in group activities), (3) respect (includes respect for the input/expertise of others, willing to learn from each member in the group , asking group members for ideas and opinions in making decisions), (4) providing encouragement (students openly praise team members who work well, encourage and empower team members, make team members feel strong and important), (5) building team spirit (including creating a friendly atmosphere and work morale, resolving disputes happening within the group, protecting/promoting the reputation of the group). Collaborative ability is the result of coordinating individuals in groups, then producing joint performance (Yang et al., 2021). Collaborative ability was analyzed using observation sheets.

Normality

Table 4.2 discuss the significance value of each item is greater than a = 0.05. This shows the variance between groups of data is homogeneous Based on the table, it can be seen that the significance value for the experimental class pretest is 0.076 > 0.05, then the

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posttest value for the experimental group is 0.200 > 0.05, the control class pretest value is 0.061 > 0.05, and the control class posttest value is 0.087. > 0.05. Therefore, because all values of the experimental class and control class, both pretest and posttest > 0.05, it can be concluded that the data is normally distributed.

Table 4.2 Normality Test

Kolmogov Smirnov Characteristics Test	**Kelas Eksperimen**		**Kelas Kontrol**		**Hasil**	**Interpretasi**
	Pre test	***Post test***	***Pre test***	***Post test***		
Sig.	0,076	0,200	0,061	0,087	Sig > α	Berdistribusi Normal
A	0,05	0,05	0,05	0,05		

Variance Homogenity Test

The homogeneity of variance test was conducted to determine whether each group of data and the overall data had a homogeneous variance or not. To test the homogeneity of the data variance, Levene's statistical test was used which was carried out with the help of IBM SPSS Statistics software. The hypotheses and test criteria are:

- H0: The variance between data groups data is homogeneous
- Ha: The variance between data groups is not homogeneous
- Test criteria: reject H0 if the significance value of Levene's statistical test is < 0.05 and accept
- H0 if the significance value of Levene's statistical test is > 0.05

The output of the homogeneity of variance test results can be seen in the following **Table 4.3**.

Table 4.3 Test of Homogenity of Variances

		Levene Statistic	**df1**	**df2**	**Sig.**
PRE TEST	Based on Mean	5.630	1	56	.071
	Based on Median	5.859	1	56	.091
	Based on Median and with adjusted df	5.859	1	53.233	.091
	Based on trimmed mean	5.682	1	56	.071
POST TEST	Based on Mean	.020	1	56	.887
	Based on Median	.019	1	56	.890
	Based on Median and with adjusted df	.019	1	55.796	.890
	Based on trimmed mean	.014	1	56	.905

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Based on the table, the significance value of each item is greater than a = 0.05. This shows the variance between groups of data is homogeneous. N-Gain test analysis was carried out to see the increase in the ability of the experimental class to the control class.

Ability Data Analysis (N-Gain Test)

Based on the **Table 4.4**, N-Gain test analysis was carried out to see the increase in the ability of the experimental class to the control class. Based on the **Table 4.4**, it can be seen that the N-Gain value for the experimental class is -0.3365 and for the control class is 70.4132, this shows that the experimental class and control class have different increases, where in the control class there is an increase in reducing/decreasing when compared to the experimental class that is in the high improvement category.

Table 4.4 N-Gain Test

	N	Minimum Score	Maximum Score	N-Gain	Category
Control	28	-75	36.36	-0.3365	Reduce/Decrease
Experiment	30	17.65	100.00	70.4132	High

T-Tabel Test

From the **Table 4.5** above it is found that the significance level is 0.011 where the number is smaller than 0.05, it can be concluded that Ho is rejected and Ha is accepted. It can be explained that after the research, there were differences (as seen from the increase in learning outcomes) in the creative thinking abilities and collaborative abilities of students who received STEM-integrated project-based learning models from students who only received conventional learning methods.

Table 4.5 Group Statistics

Group	N	Mean	Std. Deviatiation	Std. Error Mean
Skor 1	30	60.5000	17.11170	3.12416
2	30	80.7667	10.42439	1.90322

Creative Thinking Ability

The research carried out produces data in the form of quantitative data. The data was obtained using a test of students' creative thinking skills on the STEM integrated project-based learning model on Theme 9 Kayanya Negeriku and Sub Theme 4 Karyaku Prestasiku. The material in the learning of the first and second meetings is learning Natural Sciences and Mathematics. Science is related to efforts to preserve natural resources, Mathematics is related to the area and perimeter of a rectangle. The third and fourth meetings are the same learning, namely science, mathematics plus Indonesian language learning related to

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energy-saving posters. The increase in students' creative thinking skills was obtained from the results of the pretest and posttest scores that took place in learning activities.

Before the treatment was carried out, there were facts that the researchers found that at State Elementary School Cilengo and State Elementary School 9 Pamuruyan showed the low ability of students in developing their potential. Most students find it difficult to think creatively to solve the problems given and have not optimally communicated their ideas either individually or as part of a group during the learning process. This is the impact of learning that seems boring, resulting in students being less active in learning and less enthusiastic about paying attention to the teacher's explanation. Before the treatment of the STEM integrated PBL model, students rarely asked questions when faced with things that they felt were difficult to underst and. Students only answer questions/problems according to the examples that have been given, students do not have will to look for alternative answers so that the answers presented are not diverse. The existence of creativity in learning is expected that students have the courage to solve a problem in their own way. Creativity will occur if the knowledge learned / acquired is used adaptively and creatively (Gube and Lajoie, 2020).

Based on the results of the study, besides being seen from the measured values, there were various changes in the experimental class treated with the STEM integrated PBL model related to creative thinking skills. The students changed their abilities, especially in giving opinions and asking questions. The students after the treatment became more able to play an active role as individuals in the form of individuals and individuals as part of groups. Students based on their roles are able to provide various ideas until ideas emerge as a very diverse problem solving responses. They expressed their thoughts either questions or in the form of answers include the original results of the students' thoughts observing and exploring themselves during teaching and learning activities. Because the treatment in the experimental class presents learning by directly observing certain objects, eliciting opinions, ideas and perceptions from students in detail. This is what distinguishes the increase in the ability of the control and experimental classes or the class that is treated with integrated PBL from the conventional model treatment.

The indicators used in this study related to the ability to think creatively are (1) fluency, which is the ability to generate many ideas, (2) flexibility is the ability to provide various opinions as solutions/approaches in overcoming problems that arise in learning activities. Flexibility is related to the success of identifying problems as conditioning in learning which then generates ideas as innovative solutions to the problem, (3) original thinking is the ability to express ideas in a different way as the embodiment of the students' own thinking (not cliché) (Yang et al,. 2018). Creative thinking in which there is the ability to produce original and useful responses, refers to high-level cognitive resources, (4) elaborative thinking (elaboration) is the ability to describe a thing/way in detail (Jenni et al., 2020).

Besides the pretest and posttest scores, it can be seen that there is a significant difference between the average N-gain in the control class and the experimental class. It can be seen in table 4.4 that the increase in creative thinking skills in the experimental class is at a high level. On the other hand, based on the results of N-gain, it can be said that the control class based on the value of creative thinking ability is at a decreasing level. This is because the condition after treatment, students experience a decrease or condition of the value that actually decreases instead of increasing. This happens because students feel that the questions have been given previously so that they do not work carefully.

After processing the results of the pretest and posttest scores from the experimental class and control class, to prove whether or not there is an effect of STEM integrated

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project-based learning on students' creative and collaborative thinking skills, statistical tests are carried out for both classes with normality test, homogeneity test, and hypothesis testing. In table 4.2 it can be seen that the two classes (experimental and control) are normally distributed. In table 4.3 it can be seen that both classes (experimental and control) have homogeneous variance. Regarding the hypothesis test, it can be seen that the experimental class and the control class have significant differences.

Therefore, the ability to think creatively by using an integrated STEM project-based learning model is superior to conventional learning models. This shows that the conventional learning model is not always bad, but because the learning in sub-theme 4 related to karyaku prestasiku or my work is real, it is better to improve the learning model by applying and then linking learning to things that exist in everyday life. This is to make it easier for students to have better understanding an apply what is going on in learning.

Collaborative Ability

Collaborative ability is the ability to work effectively and show respect for other team members, exercising fluency and willingness to make decisions needed to achieve common goals. Teachers should create situations for students to be able to group together, so as to create a democratic atmosphere, respect differences of opinion, be aware of mistakes made, and foster a sense of responsibility. Collaborative abilities are obtained from learning experiences with practice (Covington, 2021).

In the preliminary study, related to collaborative abilities, it was found that in Cilengo State Elementary School Pamuruyan 9 State Elementary School there was a low ability of students to work in groups/collaboratively. When carrying out group activities, students only wait for answers from certain people without any tips for contributing thoughts, ideas or other contributions. This makes students only focus on one answer and are not challenged to think about other alternative answers so that the answers produced are varied. The students in this preliminary study only actively asked about the clarity of instruction and had a very difficult time giving original new ideas, answering questions only modestly (very briefly) and did not try to give broad and satisfactory answers.

Based on the research, the results obtained regarding collaborative abilities is an increase. Where the increase in the experimental class is more significant than the increase in the control class (it can be seen in the attachment of the value of collaborative ability of the experimental class and control class). Based on the collaborative ability observation sheet, it was found that most of the students' collaborative abilities were at a very good level.

The application of the STEM integrated PBL model allows students not only to develop intellectual skills, but also to be able to form their manual skills. STEM-integrated PBL helps students to be able to solve given problems related to materials that are adapted to environmental conditions, it helps students find new ideas, create a work/product based on theoretical concepts or information obtained.

Students' collaborative abilities honed with STEM-integrated PBL provides learning opportunities to autonomously construct knowledge and then create real products. After implementing STEM-integrated PBL, students significantly become able to socialize with other people, then how to study in groups with project assignments produces work after the learning process ends. State that collaboration will ultimately show the personal characteristics, knowledge, experience and skills of teachers/students (Weinberger and

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Shonfeld, 2018). Collaborative ability is the result of coordinating individuals in groups, then producing joint performance (Yang et al., 2021).

Based on the research, the STEM approach in learning is able to produce meaningful learning, the resulting meaning can be implemented in everyday life. The students were more enthusiastic in STEM-integrated PBL learning because in its implementation it was not just theory that was taught. The students carry out the practice with the aim of students experiencing the learning process directly. By experiencing the learning process first and, students in research after treatment can more easily solve the problems presented and actively provide comments to each other on the problem as answers to problems, answers and comments vary, students are able to play an active role as individuals who are part of their respective groups. Things like this are very obvious in the facts related to the differences in students' collaborative abilities in the experimental class and control class or classes with STEM integrated PBL treatment and conventional models. Increased enthusiasm of students when they have received treatment can be called self-motivation. Study is regarding motivation, namely in the form of self-evocation of learning, activeness in groups which in the end can be seen directly with the size of the number in the form of value (Lin, 2019).

4. CONCLUSION

From the explanation above, it can be concluded that the STEM integrated project-based learning model is effective for improving the creative thinking and collaborative abilities of elementary school students. The improvement of creative thinking skills after the implementation of the STEM integrated PBL model treatment is that apart from the value generated in the form of numbers, there are certain attitudes that have increased such as fluency, flexibility and originality. The improvement of collaborative abilities after the implementation of the STEM integrated PBL Model is not only numerical value of the resulting product and an assessment of the observation sheet which shows the results of most students showing very good scores, but also there are other results related to attitudes during learning. After the treatment, students experienced several improvements including being more confident, having a positive attitude, being more able to respect other students in the same group, having better ability to provide support to friends in their group, students being more able to build mutual enthusiasm in the group (encouraging each other).

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