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The Effect of the Project-Based Learning (PjBL) Model based on an Integrated STEM Approach with Entrepreneurial Character on Students' Creative Thinking Ability

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Abstract

This research aims to measure students' creative thinking abilities using the Project-Based Learning (PjBL) model based on an integrated STEM approach with entrepreneurial character in dynamic electrical material. This type of research is quasi-experimental with a none-equivalent pre-test and post-test control group design research model. The population in this study was all students in class XII phase F, with a total of 8 classes. The sampling was taken using cluster random sampling. Class F4 is an experimental class with 35 people, and class F3 is a control class with 35 people. The experimental class implemented STEM-based PjBL integrated entrepreneurial character and the control class with conventional learning. The instrument used was a 4 question description test to measure creative thinking. Based on the t-test, it was found that the initial abilities in both classes were the same in terms of creative thinking skills. The average post-test score for the experimental class and control class. Based on the t-test, there is a significant difference, which means there is an influence of STEM-based PjBL integrated with entrepreneurial character on creative thinking skills.

Keywords: creative thinking; entrepreneurial character; Project-Based Learning (PjBL); STEM

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INTRODUCTION

In the 21st century era of education, students are required to have 4C skills that can help them face world developments and the challenges of the development of science and technology education, which is developing very quickly and becoming increasingly sophisticated. This is in line with (Prameswari & Anik Lestariningrum, 2020; Drakos et al., 2021; Wibowo, 2023). Students need to master four concepts, namely 4C, critical thinking, communication, collaboration, and creativity, where the learning process will pass on skills to get used to current conditions.

Changes in the Indonesian education system, including the Merdeka Curriculum, aim to develop a more holistic student character, including entrepreneurial character. The Merdeka Curriculum is designed to introduce a more contextual and relevant learning

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approach that empowers students to face real-world challenges. Progress in the world of education with the implementation of a Merdeka Curriculum. The Merdeka Curriculum provides students with entrepreneurship projects to strengthen the Pancasila student profile. This requires students to have an entrepreneurial character.

Entrepreneurship can be seen from various aspects of personality, such as a person's soul, character, attitudes, and behavior. The indicators used as measurements of entrepreneurial character are self-confidence, independence, discipline, optimism, task, and results-oriented, leadership spirit, openness to criticism and suggestions, courage to take risks, and originality (innovative, creative, and flexible) (Polindi, 2019; Mccormick et al., 2018; Lailatussaadah et al., 2020).

The Merdeka Curriculum carries a project-based learning method that encourages students to develop their business ideas, design business plans, and even try running small business projects. Therefore, the PjBL model is highly recommended in Merdeka Curriculum learning. There are several advantages of PjBL in physics learning, namely accommodating students' positive attitudes towards learning, fostering curiosity, stimulating enjoyment of learning, guiding active and creative involvement in learning, encouraging collaborative independent learning, and building close personal and social relationships between students and information literacy. And technology relationships between students and information literacy and technology" (Santyasa et al., 2020). PjBL is project-based learning using media. Students are guided to explore, assess, interpret, and organize systems and knowledge in groups and then present them which are useful for the student learning process (Pratiwi et al., 2020; Wanglang & Chatwattana, 2023;.Becerra-Posada et al., 2022).

STEM in PjBL also provides challenges for students because it is able to train students to think creatively, analyze, and improve high-level thinking skills. Thus, combining the PjBL model with the STEM approach can optimize learning activities that support achieving success. Learning on mastering creative thinking concepts and skills (Afifah et al., 2020; Mukaromah & Wusqu, 2020; Rusman et al., 2021). STEM education aims to encourage students to have scientific and technological literacy as evidenced by reading, writing, observation, and scientific research. This aims to develop their ability to deal with daily problems (Retnowati et al., 2020). The STEM model can help develop knowledge, help answer questions based on investigations, and help students create new knowledge (Nasrah et al., 2021).

STEM integration has been defined as integrating science, technology, engineering, and mathematics into solving real-world problems based on students' experiences to enhance 21st-century skills; this is in line with the opinion Sulaeman et al., (2020) "STEM integration has been defined as integrating character, technology, engineering, and mathematics to solve real-world problems based on the students' experience to improve 21st-century skills."

Using STEM Learning in the Education sector aims to prepare quality students to compete and be ready to work in their field (Fathoni et al. ,2020). Through the STEM approach, the learning process will be through applying and practicing basic STEM content in real-life situations, discussing science, and linking it to technology, engineering, and mathematics (Siswanto, 2018). According to Izzati et al. (2019), Learning with a STEM approach focuses on a learning process

that explores two or more areas where students are actively involved in real-world problem-solving.

According to Suryana (2021), a successful entrepreneur has five key characteristics, including (1) daring to start something, (2) being responsible for bearing uncertainty and risk, (3) being an innovator, (4) discovering opportunities and taking advantage of them, and (5) have managerial abilities. Meanwhile (Yusuf et al., 2019). Entrepreneurship is also considered superior because of its ability to seek opportunities and bear risks (Rama et al., 2022). Entrepreneurship education consists of activities that aim to stimulate people's mindset about entrepreneurship and develop their potential by expressing creative and innovative behavior (Indriyani, 2017).

Creative thinking ability is the ability to create something new. As a teacher, you must be able to develop students' creative thinking using appropriate learning modes. Creative thinking can be trained according to the subject matter (Nita & Irwandi, 2021). Students who have creative thinking abilities will be able to find solutions in new ways. (Nasir & Jayanti, 2021). There are three aspects of creative thinking: fluency, flexibility, and novelty/originality (Khairiah & Amir, 2019; Zakiah & Fajriadi, 2020).

Based on initial observations at SMAN 10 Jambi City, by conducting interviews with study teachers, especially physics, information was obtained that the school implemented a Merdeka Curriculum. As is known in the Merdeka Curriculum, students are required to have the ability to think creatively and have entrepreneurial character. The teacher said that the students' creative thinking and entrepreneurial character were relatively low. This was noticed when the teacher was teaching; it was very rare for students to give opinions when asked questions by the teacher, and there was curiosity and lack of discussion.

Based on the teacher's observations, students' entrepreneurial character is very low. This can be seen when the teacher gives group assignments or projects. In the group, there is no innovation, self-confidence, or courage to take risks, and only 1 or 2 people do the rest, actively participating in discussions and expressing their opinions. Teachers say that students' low creative thinking abilities and entrepreneurial character impact learning outcomes and the subsequent learning process. Apart from that, the teacher said that it was difficult to explain physics material, especially dynamic electricity material in dynamic electricity. There were several difficulties when the teacher presented the material, namely when the teacher explained the process of electric current, even though electric current was no longer common in everyday life. So teachers are interested if there is a solution to explain dynamic electrical material that makes students understand dynamic electrical material. Using inappropriate learning models can cause low creative thinking abilities and entrepreneurial character.

One of the learning models recommended for use in Merdeka Curriculum learning is the project-based learning model. Appropriate learning methods and the use of teaching materials must also be appropriate so that students' thinking skills are well-trained (Yulia & Ramli, 2019). Based on the problems found by researchers, a learning model should be needed to train students' creative thinking abilities and instill entrepreneurial character while still focusing on the material concept. One of them is a STEM-based project-based learning model integrated with entrepreneurial character.

Based on the background that has been explained, it is necessary to

conduct research titled "The Effect of the Project-based Learning (PjBL) Model based on an Integrated STEM Approach with Entrepreneurial Character on Students' Creative Thinking Ability on Dynamic Electrical Material in High School". This research aims to measure students' creative thinking abilities using the Project-Based Learning (PjBL) model based on an integrated STEM approach with entrepreneurial character in dynamic electrical material.

METHOD

The research was a quasi-experiment with a none-equivalent Pre-test and Post-test control group design research model. This research was conducted at SMA 10 Jambi City Class XII Science. The population in this study was all Class XII Science at SMA 10 Jambi City with a total of 8 classes and a total of 280 students, while the sample was Class XII Science 1 and II with a total of 70 people. Because this type of research is quasi-experimental. The sampling technique used in this research was random sampling. This is to choose one class as the experiment class and the other as the control. This study provided two conditions, so the group was divided into experimental and control classes with different treatments determined from the beginning using total sampling. Class XII F4 is the test class, and Class XII is the F3 controller. The research instrument in this study is a test instrument. In the form of creative thinking ability test questions, the test used is a written test in the form of essays given in the form of pre-test and post-test totaling four questions using creative thinking indicators.

RESULT AND DISCUSSION

This research was conducted on class XII F students at SMA Negeri 10 Jambi City in the odd semester of the 2023-2024 academic year. The research was conducted with four face-to-face meetings at school. This research was carried out by giving a pre-test at the first meeting, then continuing with teaching and learning activities at the second and third meetings, and ending with a post-test at the last meeting.

The results of pre-test data processing on creative thinking averaged 48.39 pre-test scores for the experimental class and 41.07 for the control class; more details can be seen in the following Table 1.

Table 1 Summary of pre-test data on creative thinking abilities

	Experiment	**Control**
$\bar{x}$	48.39	41.07
SD	15.33	11.67
S^2	235.16	136.22

Based on this data, it can be seen that the average pre-test score for the experimental class and the control class is only slightly different.

The normality test was carried out using the Kolmogorov-Smirnov test. The normality test is intended to determine whether or not the two samples come from a normally distributed population. Significance data pre-test 0.062 and 0.079, A table summary of the pre-test normality test results is shown in Table 2.

Table 2 Results of the pre-test data normality test for both classes

Data pre-test	**Statistics**	**Significance**	**conclusion**
Experimental	0.141	0.062	Normal
Control	0.144	0.079	Normal

Based on the data in Table 2, it can be concluded that the pre-test data for both classes is normally distributed with α, namely 0.062 and 0.079 > 0.05 so that the data meets normality requirements.

The independent sample t-test is used to determine whether there is a difference in the average of two unpaired samples with normal and homogeneous conditions. The results of the independent sample t-test can be seen in Table 3.

Table 3 Independent sample t-test results of pre-test data

Pre-test Data	**Sig. (2-tailed)**	**conclusion**
Students' creative thinking abilities	0.056	There is no significant difference

Based on the data in Table 3. the sig value. (2 tailed) 0.056 > 0.05, it can be concluded that there is no significant difference between the creative thinking abilities of experimental and control class students. The second class, which has the same creative thinking abilities, was given treatment in the second class to see The effect of the given processing on the students' creative thinking abilities in electrodynamic material.

After treatment for the two classes, a post-test will be given to the two sample classes. Data recapitulation was obtained from the post-test data for both classes, as shown in Table 4.

Table 4 Recapitulation of post-test data for both classes

	Experimental	**control**
$\bar{x}$	75.52	50.00
SD	13.24	15.38
S^2	175.312	236.67

Information:
$\bar{x}$ = Average
SD = Standard deviation
S2 = Variace

The normality test aims to determine whether the distribution of data in the sample group is normally distributed. Test the normal state of experimental and control post-test data using the Kolmogorov-Smirnov test. Normal state test results can be seen in Table 5.

Table 5 Post-test data normality test results for both classes

Data post-test	**Statistics**	**Significance**	**conclusion**
Experiment	0.170	0.63	Normal
Control	0.157	0.99	Normal

Based on the data in Table 5, it can be concluded that the post-test data for both classes is normally distributed with α, namely 0.63 and 0.99 > 0.05 so that the data meets the normality requirements and can be carried out further paired sample t-test in the experimental class. Meanwhile, for the further independent sample t-test, the experimental post-test data must be normally distributed and homogeneous.

Test the homogeneity of post-test data for the experimental and control classes using Levene's test for equality of variance. The homogeneity test results can be seen in Table 6.

Table 6 Post-test data homogeneity test for both classes

Data post-test	**Levene statistic**	**df1**	**df2**	**Significance**	**conclusion**
Experimental Control	0.000	1	68	0.303	Homogen

Based on the data in Table 6, the post-test data for both classes comes from homogeneous variance with α, namely 0.303 > 0.05, so the data is homogeneous. So that the data meets the requirements for homogeneity and further testing can be carried out, namely the independent sample t-test

The independent sample t-test is used to determine if there is an average difference between two unpaired samples under normal and homogeneous

conditions. The results of post-test t-test data for independent samples can be seen in Table 7.

Table 7 Results of independent sample t-test post-test data

Post-test data	**Sig. (2-tailed)**	**Conclusion**
Students' creative thinking abilities	0.000	There are significant differences

Based on the data in Table 7, it can be concluded that there is a significant difference between the creative thinking ability of experimental and control class students. The two groups have different creative thinking skills, so a multiple-sample test will follow in a pilot class to see the effects of the specific treatment.

Paired sample t-test is used to determine whether there is a difference in the average of two paired samples. Two paired samples, namely the same sample, namely the experimental class, have two data sets: pre-test and post-test. Paired sample t-test is a part of parametric statistics with the condition that the data is normally distributed. Post-test data are tested for normality with normally distributed data results. The results of the paired sample t-test can be seen in Table 8.

Table 8 Results of paired sample t-test for experimental class

Data	**Sig. (2-tailed)**	**Conclusion**
Experiment	0.000	There is a significant difference in students' creative thinking abilities

Based on the data in Table 8, it can be seen that there is a significant difference between students' creative thinking ability in the pre-test and post-test with $\alpha = 0.05$. So, it can be concluded that by providing an integrated STEM-based PjBL model, entrepreneurial character influences students' creative thinking abilities in dynamic electrical material.

The research results show a significant impact on students' creative thinking abilities in students who are given learning treatment using the STEM-based PjBL model integrated with entrepreneurial character. This is shown in Table 7, where there is a significant difference in students' creative thinking abilities before and after being given treatment. The activity carried out by the students was to create a project related to dynamic electrical material. The project was created as a portable night light using series, parallel, and series-parallel circuits.

Implementation of learning in the experimental and control classes took place face to face at school with a total of 4 meetings, but two meetings for learning (3x45 minutes) and two meetings for pre-test and post-test were held during physics learning hours with 45 minutes before the next lesson. There were 35 students in both the experimental and control classes. This development can be seen from the significant differences in the results of students' creative thinking abilities. Classes that apply STEM-integrated PjBL learning have higher creative thinking abilities than classes that apply to learning using conventional methods.

The ability to think creatively tends to train students to express ideas that arise or express themselves in the learning process. The ability to think creatively is important in the world of work (Wahyuni & Kurniawan, 2018; Hormadia & Putra, 2021; Prasetya Subakti et al., 2021). Thinking creatively is an important skill in many fields, including science, engineering, arts, and business, because it allows individuals to approach problems in new and unconventional ways, leading to breakthroughs and innovations (Mursid et al., 2022).

Creative thinking ability has four indicators: fluency, flexibility, originality, and elaboration (Ananda et al., 2021). According to Sari & Angreni (2018) Something new is an indicator of creative thinking in science, but other indicators are logical thinking and divergent thinking.

Project-based learning allows students to engage in open-ended and complex tasks that require students to generate new ideas, perspectives, and solutions. Additionally, project-based learning often involves collaboration and feedback, which can help students refine and improve their ideas over time. The authors argue that project-based learning is a promising approach for improving creative thinking abilities and 21st-century skills (Somphol et al., 2022). The project learning model can train students to be more active individually and in groups, and PjBL is innovative learning that focuses on students (student oriented) and places teachers as motivators and facilitators; in this case, students are allowed to work independently to build their learning (Biazus & Mahtari, 2022; Soleh, 2021; Surya et al., 2018).

The increase in students' creative thinking abilities with STEM-integrated PjBL in the experimental class is in the medium category. This is shown by the average normalized gain test increasing by 52% for the experimental class and 15% for the control. The pre-test results of students in the experimental and control classes can be seen in Table 1. namely 48.39 for the experimental class and 41.07 for the control class, while the post-test results of students after giving treatment increased; this can be seen in Table 4 for the experimental class the average post-test score was 75.52 while for the control class 50.00 means that there is a much higher increase in the class that uses the STEM-based PjBL model integrated with entrepreneurial character.

According to Permata et al. (2018), by utilizing a project-based learning model, students work together, take responsibility, accept each other, and provide input because it is done in groups, and the result is a quality product. Therefore, using the PjBL model helps students develop creative thinking skills; apart from using the PiBL model, a STEM approach is also used.

The learning process, which begins with determining basic questions, designing project plans, preparing schedules, monitoring project progress, testing student learning processes and outcomes, and evaluating student learning experiences, cannot be separated from researcher observations. The researcher observed each student's activities through observation sheets prepared by the researcher. The observations were made of groups of students that had been formed. This learning process shows students' enthusiasm to dive straight into project creation. Through this process, students experience the stages of learning themselves so that their' creative thinking abilities develop.

STEM is a learning approach that focuses on educating students in four scientific disciplines. STEM education can make student learning more relevant and meaningful, deepening student understanding (Davidi et al., 2021; Purnamasari et al., 2020; Sukmawijaya et al., 2020). STEM education is an interdisciplinary learning approach, combining rigorous academic concepts with real-world learning as students apply science, technology, engineering, and mathematics in contexts that make connections between schools, communities, jobs, and global corporations. STEM has better educational outcomes in education and places it in context, such as improving life skills, career development, and expanding the global economy. For

example, and improving academic achievement, improving 21st century skills (Razi & Zhou, 2022).

The project-based learning method allows students to work independently or in groups to produce project results that arise from everyday problems (Nurfitriyanti, 2016). An entrepreneurial character is used to help develop creative thinking skills, which can develop students' mindsets in the 21st century.

Entrepreneurship also has the will, skill, and readiness to start a business and accept the consequences, profit or loss. (Rama et al., 2022). Entrepreneurship education consists of activities that aim to stimulate people's ideas or mindset about entrepreneurship and their thoughts, attitudes, and abilities to develop their potential by expressing creative and innovative behavior (Indriyani, 2017).

According to Umamah & Andi (2019), the ability to think creatively is very important in the world of education because, with the ability to think creatively, students will be able to make the right decision in a problem (Handoko et al., 2022). Creative thinking ability has four indicators: fluency, flexibility, originality, and elaboration (Ananda et al., 2021).

In general, the learning meetings that have been held show that the ability to think creatively through creating projects in groups makes students develop the ability to think creatively and have an entrepreneurial character. Each PjBl syntax is integrated with entrepreneurial characteristics such as independence, creativity, courage to take risks, action orientation, leadership spirit, hard work, and an honest attitude.

The STEM and entrepreneurial characteristics in this research lie in the PJBL syntax in the teaching module. Using a STEM approach in teaching modules allows students to solve problems and create meaningful understanding to improve their creative thinking abilities. The use of an integrated STEM-based PjBL model. Entrepreneurial character influences students' creative thinking abilities. The table shows that the increase in creative thinking abilities of experimental class students is much higher than that of the control class, which uses conventional learning.

CONCLUSION

The following conclusions were obtained based on research on the influence of the STEM-based PjBL model integrated with entrepreneurial character on the ability to think creatively in dynamic electrical material in class XII. There is a significant influence on the ability to think creatively in dynamic electrical material in class. From the average post-test experimental score of 75.52 and the control 50.00 based on the t-test, the integrated STEM-based PjBL model of entrepreneurial character significantly influences the ability to think creatively in dynamic electrical material.

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