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STEM-PjBL and creativity of science learning students in elementary schools

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ABSTRACT

Science learning is a lesson that studies nature and life. Science learning opens up opportunities for students to ask questions, develop new ideas, and build new skills, so this research aims to describe the implementation of STEM-PjBL, measure student creativity after implementing STEM-PjBL, and measure the influence of STEM-PjBL in science learning. This research uses a quantitative approach with the Pretest-Posttest Nonequivalent Control Group Design type. In this design, there are two groups: the experimental and the control groups. Data collection techniques use observation. The subjects used were 58 students, consisting of 28 as an experimental group and 30 as a control group. Data analysis techniques include a paired sample t-test and an independent sample t-test with a significance level of 5%. There is an increase in student creativity in the learning process. The results of the paired sample t-test show that there are significant differences in student creativity after the STEM-PjBL action in learning. The results of the independent sample t-test show that there are significant differences in STEM-PjBL actions in the learning process. STEM-PjBL has an influence on student creativity in the learning process.

1. Introduction

Science learning is a lesson related to nature and human life. Natural science is directly related to daily life in the surrounding environment (Maryanti et al., 2023)—science learning studies real-life events (Puspita et al., 2023). Science learning is important so that students can understand how to interact with the environment, understand the universe and the environment, and how to work and survive (de Leon et al., 2016; Kind, 2016; Nathan et al., 2024). It opens up opportunities for students to ask questions, develop new ideas, and learn new skills so that creativity can emerge and improve learning outcomes. However, science learning in elementary school teachers still uses conventional methods, so the material taught is not conveyed optimally, and there are not enough active students (Hanif, 2020).

The teacher's learning process needs to develop student creativity. Creativity plays a central role in education, surviving, and adapting to change (Yulaikah et al., 2022). According to Maarang et al. (2023), creativity is the ability to generate new ideas or create innovations that can be used to solve problems or identify new relationships between existing elements. Creativity encourages the progress of all disciplines, benefiting individuals and society (Maryani et al., 2023). Creativity is an individual's ability to present something new (Dong et al., 2017), either in the form of active, creative, affective thinking in the form of new models or a combination with existing ones, thus making learning more enjoyable and helping students develop creativity.

Creativity has several indicators, but in this study, researchers used the indicators of curiosity, imagination, feeling challenged by diversity, and the courage to take risks (Albar & Southcott, 2021; Chen et al., 2020). The factors for creativity include: a) respecting children's opinions and encouraging children to express opinions (Dere, 2019); b) letting children make their own decisions (Wei et al., 2015); c) encouraging children's difficulties to explore and question everything (Lian et al., 2018; Sitorus & Masrayati, 2016); d) supporting and encouraging children's activities (Wei et al., 2015); and e) giving praise to the child sincerely. The inhibiting factors for creativity are a) evaluation in fostering creativity, which the teacher postpones; b) giving gifts that can damage children's motivation and discourage creativity; c) complex competition rather than giving children evaluations or prizes; and d) an environment that limits children's creativity and learning. Some students are not actively exploring and expressing their creative ideas during learning. When given the opportunity by the teacher, some students are more interested in playing and pay less attention (Muhanif et al., 2021). Some students also tend to imitate existing examples or information they have received, so their work tends to be similar (Urip, 2021).

Student creativity in the learning process can be developed with the STEM approach, which integrates science, technology, engineering, and mathematics into one comprehensive unit effectively in the context of learning activities relevant to everyday life (Nurhaliza et al., 2021). This approach can increase student motivation, creativity, and learning outcomes in science learning, including solving problems, expressing ideas, thinking logically, and developing skills, independence, and technological proficiency (Wahyuni, 2021). However, according to Sumaya et al. (2021), students are still weak at conducting experiments or trials, less accustomed to solving problems, and passive in groups.

The STEM approach can be carried out using the project-based learning model. Implementing this model at the beginning of learning uses problems as the first step in collecting and integrating new knowledge, and the teacher acts as a facilitator (Fahrezi et al., 2020). Project-based learning focuses on students and is free to explore and carry out projects collaboratively by producing work or products in the learning process. The PjBL model has six steps: preparing basic questions, designing project plans, preparing schedules, monitoring project activities and progress, testing results, and evaluating project processes and results. Thus, the PjBL model can encourage student creativity, critical and scientific thinking, independence, responsibility, and self-confidence and improve student learning outcomes. However, in practice, students' creativity is sometimes low because they have difficulty applying their ideas to make products, even though they have many ideas (Widiastuti et al., 2018).

Procedures have not implemented the project-based learning model implemented by teachers, so teachers are still dominated in the learning process. As a result, student involvement in learning is weak, and student interest, motivation, and creativity are also low (Fitriyani et al., 2020). Applying STEM-PjBL to energy transformation material in fourth-grade elementary school science learning is expected to increase student creativity, encourage students to become actively involved in learning, and increase student interest, motivation, and creativity. So, it can have positive implications for increasing students' creativity in learning, especially in Grade IV Elementary School Science.

Several studies have examined the success of the PjBL learning model and the STEM approach. Project-based learning successfully improved science learning outcomes and process skills (Schneider et al., 2022). This learning model has been modified with a STEM approach to have more advantages (Maryani et al., 2021). This learning model has been modified with a STEM approach so that it has more advantages. This research has three objectives, namely: (1) describe the procedures for implementing STEM-PjBL in learning, (2) measure student creativity after implementing STEM-PjBL, and (2) measure the influence of STEM-PjBL on student creativity in learning.

2. Method

2.1. Research design

This research used a quasi-experiment with a pretest-posttest, non-equivalent control group design. There are two sample groups: the experimental and the control groups. Both were given initial s generalized to other conditions that may be similar (Yarkoni, 2022).

2.2. Participants

This research involved 58 elementary school students divided into two groups in grade 4. Then, the two groups were randomized to determine which would be the experimental group and which would be the control group. A sample of 28 students was obtained for the experimental class and 30 students for the control class. Simple random sampling is used so that research results can be generalized to other conditions that may be similar.

2.3. Data collection tools

Data collection uses observation of learning implementation and observation of student creativity. The implementation observation instrument is based on the Project-based learning model syntax from introduction to conclusion contained in teaching modules that are integrated with STEM, namely mastery of the material (Science), mastery of mathematics related to material and projects (Mathematics), mastery of technology related to material and projects (Technology), and mastery of engineering used in projects or engineering. Where the instrument uses the Guttman scale (1 = yes, and 0 = no). Then, use the Guttman scale (1= = yes, and 0 = no) for the creativity observation sheet. In the creativity instrument, there are 13 item points used to measure student creativity, where the 13 items are the result of 4 indicators of creativity, namely curiosity, which is made into four sub-indicators; imaginativeness, which is made into three indicators; feeling challenged by diversity, which is made into three sub-indicators, and a courageous attitude. In taking risks, it is divided into three sub-indicators. Before using the instrument to gather data, experts validate it to make sure it is reliable and valid. The instrument blueprint can be seen in Table 1.

Table 1. Blueprint guide observing student creativity

Variable	Indicator	Item
Creativity	Curiosity	1,2,3,4
	Imaginative	5,6,7
	Feeling Challenged in Diversity	8,9,10
	Dare to Take Risks	11,12,13

2.4. Research procedure

The research began with initial observations as a pretest of the creativity variable. Four observers who had gone through perception equations observed both groups. The second step is learning with STEM-PjBL for the experimental and STEM-PBL for control classes. Consider choosing other measures to test the robustness of STEM-PjBL when compared with equivalent treatments. Treatment was given in two meetings for each group. In each treatment, observers carry out their duties to see the emergence of indicators of creativity in students. Four observers who had gone through the perception equation made the initial observations as a pretest of the creativity variable. The experimental group was given a treatment in the form of STEM-PjBL, which was carried out over two meetings. In each treatment, observers carry out their duties to see the emergence of the creativity indicators used in this research. Then, the observer writes the results on a creativity observation sheet. Finally, an analysis of the data that has been collected is carried out. This analysis describes the implementation of STEM-PjBL in learning energy transformation material and analyzes creativity before and after treatment.

2.5. Data analysis

Descriptive statistics are used to analyze the implementation of STEM-PjBL in the experimental class. A paired sample t-test was used to measure the difference in mean creativity before and after STEM-PjBL treatment in the experimental class. Next, differences in post-treatment creativity in the experimental and control classes were analyzed using the independent sample t-test.

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3. Results and Discussion

The implementation of STEM-PjBL was carried out in two meetings. The percentage of implementation of its model is presented in Figure 1.

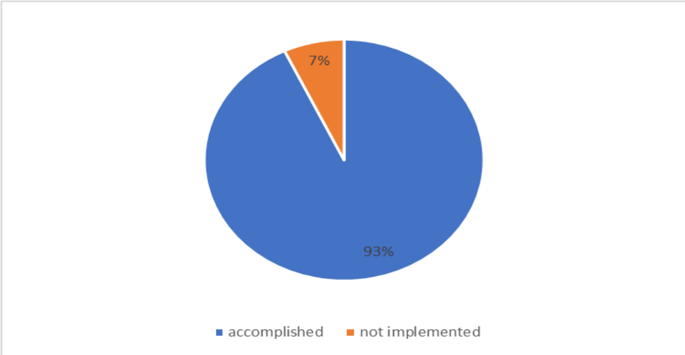


Fig. 1. Percentage of implementation of the PjBL STEM Model

The first meeting begins with greetings, asking about news, praying, checking attendance, ice-breaking, motivating students, showing appreciation, and conveying learning objectives. In the first syntax, the teacher shows a picture and asks the students, "What results when both hands are rubbed?". Then, students are asked to name objects around them that utilize energy changes (science). Apart from that, the teacher shows pictures of waterwheels through a projector (technology), discusses how to design waterwheels (engineering), analyzes the shapes in waterwheels, such as rectangles and circles, and then asks for formulas for the circumference and area (mathematics). In the second syntax, designing a project, students are divided into five groups and given a worksheet, filling in all activities according to the instructions. In the third syntax, preparing a schedule, the students and the teacher agree on how long the work process will take and create a timeline for the activities. Fourth, by monitoring activities and project progress, the teacher sees the progress of students' work and helps students if someone asks about the worksheet. The fifth syntax tests the results; each group presents the results of their work, and each member must present, but some members still have not participated in the presentation. The sixth syntax evaluates learning processes and outcomes, summarizing the learning from the material studied.

The second meeting began with greetings, asking about news, praying, checking attendance, ice-breaking, and conveying learning objectives. The first syntax determines the fundamental question: the teacher asks, "How can the fan move and the light turn on?" and gives material about energy changes (Science), then asks students to analyze the forms of energy changes around them. The teacher also adds material about waterwheels and displays pictures of waterwheels (Technology), analyzes how to design waterwheels (Engineering), and analyzes how many tools and materials can be used to make a waterwheel (Mathematics). The second syntax is designing a project. Students are divided into five groups, and the teacher explains the instructions on the worksheet. Each group was asked to analyze the number of waterwheel materials based on variations in each group (mathematics), waterwheel design (engineering), and tools used (technology).

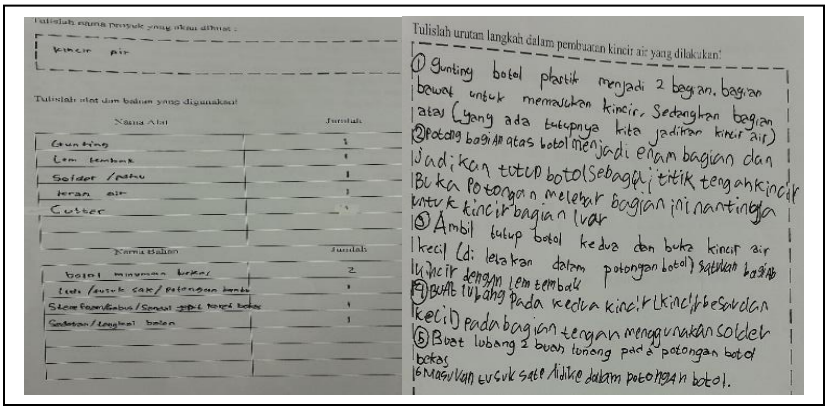
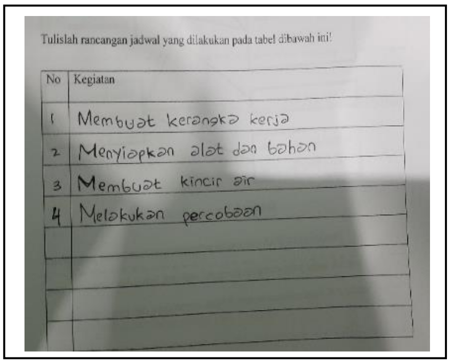


Fig. 2. The second syntax design of the project

The third syntax is preparing a schedule. Students and the teacher prepare a schedule and timeline of activities. Students are asked to fill in a timeline of project creation activities from start to finish when the product is made.


Tulislah rancangan jadwal yang dilakukan pada tabel dibawah ini!

No	Kegiatan
1	Membuat kerangka kerja
2	Menyiapkan alat dan bahan
3	Membuat kincir air
4	Melakukan percobaan

Fig. 3. Third syntax (drawing up a schedule for working on a project)

The fourth syntax is monitoring project activities and progress. The teacher monitors student activities in the project and asks students to ask questions if they experience difficulties. Students also work on questions on the worksheet, such as waterwheels' benefits. Students are asked to analyze the meaning of energy changes and energy changes resulting from waterwheels (science), make waterwheels from start to finish (engineering), conduct experiments, and analyze how waterwheels move.

Fig. 4. The fourth syntax is monitoring project activities and developments.

The fifth syntax tests the results; each group is asked to present its product, and each member must present, but in this activity, there are still students who have not presented in the group. The sixth syntax is evaluating the learning process and results. Students and the teacher summarize the material studied.

Fig. 5. The fifth syntax tests the results of project work.

The implementation of STEM-PjBL is not always carried out smoothly; several activities are not carried out, namely the provision of apperception, which does not resonate with students because some students are still chatting with their friends. In the STEM technology aspect, students do not understand what tools can be used in a water wheel and how the water wheel can function correctly. The results of measuring creativity in the experimental class in grade IV elementary school science learning both before and after being given the STEM-PjBL treatment are presented in Table 2.

Table 2. Descriptive statistics of student creativity data

No	Aspect of information	Pretest	Posttest
1	Mean	48,6	64,8
2	Median	46,2	65,4
3	Mode	38,5	53,8
4	Standard Deviation	15,2	16,7
5	Minimum	23	31
6	Maximum	77	92

The data results above were then processed again into three categories. The categorization results are presented in Figure 6.

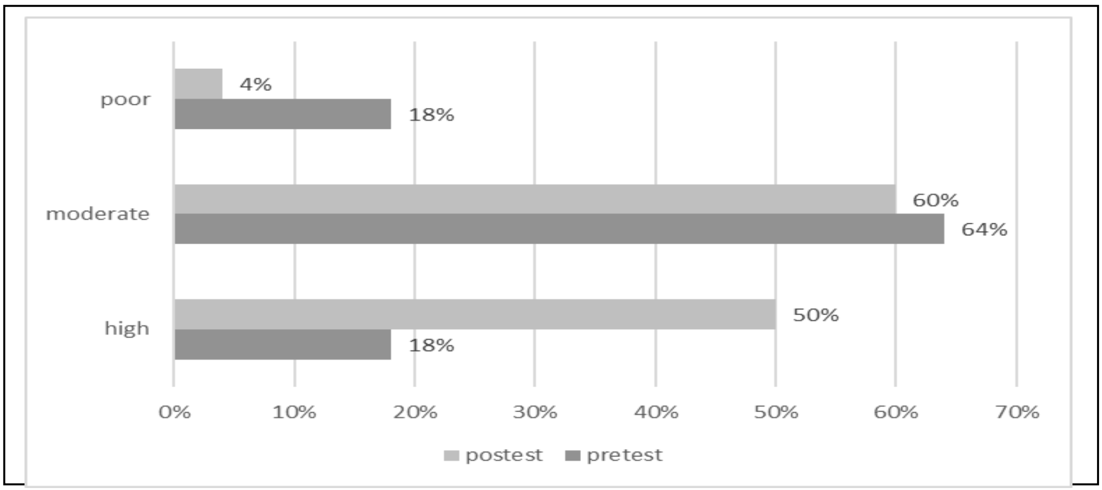


Fig. 6. Category of student creativity

Figure 6 shows that student creativity in the low category is 18%, the medium category is 64%, and the high category is 18%. It can be concluded that students' creativity before being given the STEM-PjBL model treatment was in the "medium" category. Meanwhile, in the posttest, student creativity in the low category was 4%, in the medium category was 46%, and in the high category was 50%. It can be concluded that creativity is in the "high" category. Hypothesis testing begins with analytical prerequisite tests, namely normality and homogeneity tests. The results of the normality test in this study can be seen in Table 3.

Table 3. Normality test

Pre and post	Group	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	f	Sig.	Statistic	f	Sig.
Post	Experiment-	.142	8	.157	.954	8	.247
	Control	.192	0	.006	.944	0	.116
Pre	Experiment-	.176	28	.026	.932	8	.070
	Control	.108	0	.200*	.956	0	.248

Based on the results, normality shows that each result is 0.247, 0.116, 0.070, and 0.248. The data is normally distributed because the significance value of creativity in the experimental and control classes is more significant than 0.05. A homogeneity test will be carried out after the data is said to be normal. The condition is homogeneous if the calculated significant value exceeds the specified significant degree, namely 5% (0.05). The results of the homogeneity test calculation in Table 4 are as follows:

Table 4. Homogeneity test

Levene's Test for Equality of Variances			
		F	**Sig**
Post	Equal variances assumed	1.347	.251
Pre	Equal variances assumed	.178	.674

From Table 4, the pretest data homogeneity test calculation results show that the significant value is 0.674. Based on these results, the significant value is greater than the significance table of 0.05, so it can be concluded that the pretest data is said to be homogeneous. Meanwhile, the results of calculating the homogeneity test of the post-test data show a significant value of 0.251. Based on these results, the significant value is greater than the significance table of 0.05, so it can be concluded that the posttest data is said to be homogeneous. Based on these results, the significant value is greater than the significant table of 0.05, so it can be concluded that the data is said to be homogeneous. We used a paired sample t-test at a significance level of 5% to test the hypothesis. The results of the paired sample t-test can be seen in Table 5.

Table 5. Paired sample t-test

	Paired Differences					t	F	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper			
Experiment_Pre-Experiment_Post	-19.06593	11.44474	2.16285	-23.50374	-14.62812	-8.815	7	.000

Based on the paired sample t-test on the 2-tailed sig, the results show a significance value of more than 0.05 for each pre- and post-experiment. So, it can be stated that before and after treatment, there is a significant difference in average results. The results of these measurements answer the problem formulation that there are significant differences in results after implementing STEM-PjBL in science and science learning in student creativity. The results of the independent sample t-test to test the difference in post-test means for the two groups can be seen in Table 5.

Table 6. Independent sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
Post	Equal variances assumed	1.347	.251	2.173	56	.034	7.43590	3.42117	.58246	14.28933

The results show a significance value of more than 0.05 for post-experiment and post-control, providing a significant difference. So, it can be stated that after treatment and control, there is a significant difference in the effect of the average results. The results of these measurements answer the problem formulation that STEM-PjBL significantly influences student creativity. The STEM-PjBL learning process in the first syntax is determining basic questions. In the activity in the first syntax, students are given basic questions regarding energy change material, such as "How does the fan move and the light turn on," and then asked to look for the answer from the book and complete it. This problem is solved by providing ideas, discussing how to design a waterwheel, analyzing the shapes in the waterwheel, such as rectangles and circles, and then asking for the formula for the circumference and area. The syntax of determining basic questions can influence students' curiosity, feeling challenged by diversity, and their courageous attitude in taking risks, so that it can increase students' interest, understanding, motivation, creativity, and attention in the learning process. This is in line with Malouff (2020), who states that curiosity is feeling challenged. Courage is a factor that influences student creativity and can give students a boost in knowledge and develop skills. Continuing to solve problems can influence students' curiosity.

The second syntax designs the project plan. In this syntax, students sit in groups, and there are activities to design a waterwheel project, analyze how many tools and materials are used, and learn how to design a waterwheel. This activity can increase imagination and the willingness to take risks, influencing students' creativity. This aligns with Rati et al. (2018), who found that imagination and courage can influence a person's creativity, starting with the problems or challenges given and designing to solve these problems with collaborative projects. Apart from that, this can make students think flexibly and fluently. Moreover, it increases curiosity and courage in combining and conveying ideas.

The third syntax is preparing a schedule. In this syntax, the students and the teacher determine the timeline for the implementation schedule for the waterwheel project. In this activity, students are asked to divide the tasks for each member and ask them to imagine, according to their creativity, how long it will take to complete the project. In other words, imagination can influence students' creativity. This is in line with Wulandari et al. (2019) claim that this syntax contributes to training students to think in detail and imagine regarding the allocation of time needed and focus on making products through organizing group activities.

The fourth syntax monitors project activities and progress. Students are actively involved in making waterwheel products from start to finish, working on questions on the LKPD such as energy changes in waterwheels, benefits of waterwheels, how waterwheels can move, and making reports on projects, with the teacher monitoring the progress of student projects. Making waterwheel products requires students' creative imagination, generating and collaborating on proposals or ideas in the form of products, creating designs and products that are different from others, and anticipating obstacles that might occur in the project creation process. This can affect imagination and a sense of being challenged by diversity. This is in line with Lestari et al. (2023), who say that by thinking creatively, generating ideas that are then expressed or developed into products can create different work results and train students to think about or anticipate obstacles that might occur. Students are then asked to plan, design, develop, and reflect on projects so that this activity can contribute to increasing imagination and feeling challenged by diversity.

The fifth stage of the syntax is testing the results. In this syntax, the activities carried out by students during the STEM-PjBL learning process, after completing the project framework assignment, the project report in the form of a water wheel along with the LKPD are given until completion, correctly presenting the results of the framework and products, where each member makes a presentation in turn. The syntax in these activities can influence the development of an attitude of feeling challenged by diversity and being brave enough to take risks. Developing an attitude of feeling challenged by diversity and an attitude of being brave enough to take risks can have an impact on creativity. This is in line with Rizkasari et al. (2022) that creativity finds solutions to problems by collaborating ideas, not something new that is not yet widely known and does not need to be new but rather something new for itself so that students feel challenged and brave in taking risks.

The sixth syntax is evaluating project processes and results. In this syntax, there are questions and answers regarding what was felt during the implementation of making the waterwheel, the benefits obtained, and the learning from the material that has been given. The syntax of this activity can develop a brave attitude toward taking risks because students are given problems and asked to solve them. Regarding the material that has been studied and asked to be brave in communicating what the material has been obtained, this influences student creativity. This is in line with Rokhmaniyah et al. (2021), who say that the attitude of daring to take risks in the learning process by providing opportunities for students to express answers or opinions without fear of whether the answer or opinion is correct or not can develop creativity, courage, and curiosity.

The application of the STEM-PjBL learning model has an impact on increasing student creativity. This can be seen from the observations of student creativity that have been tested before and after being given treatment. From the results of the tests that have been carried out, it is clear that students' creativity shows significant differences, or, in other words, has experienced a significant increase before and after being given the STEM-PjBL model treatment and is in the "high" category. This aligns with Widiastuti et al. (2018), who stated that this learning model can increase student creativity during the learning process, as seen in the work or products that students produce and the students' completed learning outcomes. This aligns with Yulaikah et al. (2022), who stated that the STEM approach to project-based model learning effectively increases creativity.

This research divided Student creativity into three categories: high, medium, and low. The creativity of students in the high category has the characteristics of being happy to explore new experiences, being able to solve problems, enjoying doing assignments, having a high level of perseverance, being critical of others, daring to voice opinions, daring to take risks, not afraid of failure, always wanting to know, being sensitive to feelings, having self-confidence, appreciating beauty, and being full of imagination. Student creativity in the medium category has the characteristics of being able to solve problems, having curiosity, being able to think critically, appreciating art and aesthetics, being able to express creative ideas, being brave in taking risks, not being afraid of failure, being able to express opinions, and being self-confident. Student creativity in the low category is characterized by difficulty in overcoming challenges, lack of curiosity, tending only to see problems from one point of view, difficulty combining different ideas, difficulty adapting, lack of understanding of concepts, difficulty in conveying opinions or ideas, not daring to take risks and fear of failure, lack of critical thinking skills, and difficulty expressing their ideas (Khoirin, 2023).

The challenge in implementing the STEM-PjBL learning model lies in providing apperception, and in the learning process, students still lack mastery of technology, such as what tools can be used to make the waterwheel move and how the waterwheel can function correctly. This is because a step was not implemented, namely, showing a video of the waterwheel. This needs to be done so that students can analyze how the waterwheel moves and what tools can be used. The advantage of STEM-PjBL is learning that focuses on involving students and providing meaningful student experiences. Students can be more active in collaborating and interacting to solve a problem by creating work or products.

The STEM-PjBL Learning Model can influence students' creativity in learning science. This can be seen from the test results in posttest observations with the STEM-PjBL and STEM-PBL learning models as a comparison. These results show a significant difference in mean results after receiving the STEM-PjBL learning model treatment. This is in line with Kusmiati (2022), who stated that implementing this model in the learning process significantly influences student creativity. Continuing with this model, students are expected to be able to provide support or facilities for students to have the ability to plan, implement, and evaluate their learning activities independently.

The STEM-PjBL Learning Model can provide a holistic learning experience (education that develops all students' intellectual, social, emotional, physical, and spiritual potential) in an integrated manner, where students not only learn about various concepts but also involve the application of knowledge in the context of projects. The STEM-PjBL learning model can also involve students in the learning process actively and can develop 21st-century skills such as collaboration, problem-solving, creativity, and communication to create preparation for facing the future. This is in line with the statement put forward by Nurhaliza et al. (2021): "The aim of the STEM approach, especially in education, is for students to become aware of STEM, which can be achieved by enriching themselves with knowledge, good attitudes, and skills that are by the 21st century."

The learning process using STEM-PjBL, such as making a waterwheel project, can provide a meaningful learning experience for students. Students can be actively involved in planning, implementing, and carrying out evaluations independently, which can stimulate, improve, and influence student creativity. This is because students are given the freedom to solve problems, encouraged to think critically and creatively, and involved in group work (collaborative) to build new ideas or perspectives so that creativity emerges. The results of making waterwheels can create simple products and hone and increase students' creativity. Apart from that, students are also trained to communicate ideas and the work or products they create. In other words, the STEM-PjBL model can increase student creativity through projects where students apply the knowledge they gain to problem-solving solutions.

4. Conclusion

Implementing the PjBL STEM learning model uses the syntax of determining basic questions for students, designing project plans, compiling schedules, monitoring project activities and progress, testing results, and evaluating learning processes and outcomes. This syntax is integrated into STEM for science students, who are asked basic questions related to matter, analyzing objects that use energy, analyzing energy changes, analyzing waterwheels, and technology, namely how waterwheels can rotate. Engineering designs and manufactures waterwheel products, mathematical formulas for the area and perimeter of rectangles and circles, and the number of tools and materials needed. The indicators of creativity researchers use are curiosity, imagination, feeling challenged by diversity, and the courage to take risks. Student creativity after implementing STEM-PjBL can be seen from the results. From the results of observations and tests that have been carried out, there is a significant difference in creativity after implementing STEM-PJBL in Grade IV elementary science learning, and there is a significant difference in the results of the pretest and posttest. So, it can be concluded that STEM-PjBL significantly influences students' creativity in learning science in Grade IV Elementary School.

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References

Albar, S. B., & Southcott, J. E. (2021). Problem and project-based learning through an investigation lesson: Significant gains in creative thinking behaviour within the Australian foundation (preparatory) classroom. *Thinking Skills and Creativity*, *41*, 100853. https://doi.org/10.1016/j.tsc.2021.100853

Chen, P.-Z., Chang, T.-C., & Wu, C.-L. (2020). Effects of gamified classroom management on the divergent thinking and creative tendency of elementary students. *Thinking Skills and Creativity*, *36*, 100664. https://doi.org/10.1016/j.tsc.2020.100664

de Leon, N., Jannink, J.-L., Edwards, J. W., & Kaeppler, S. M. (2016). Introduction to a special issue on genotype by environment interaction. *Crop Science*, *56*(5), 2081–2089. https://doi.org/10.2135/cropsci2016.07.0002in

Dere, Z. (2019). Investigating the creativity of children in Early Childhood Education institutions. *Universal Journal of Educational Research*, *7*(3), 652–658. https://doi.org/10.13189/ujer.2019.070302

Dong, Y., Bartol, K. M., Zhang, Z.-X., & Li, C. (2017). Enhancing employee creativity via individual skill development and team knowledge sharing: Influences of dual-focused transformational leadership. *Journal of Organizational Behavior*, *38*(3), 439–458. https://doi.org/10.1002/job.2134

Fahrezi, I., Taufiq, M., Akhwani, A., & Nafia'ah, N. (2020). Meta-analisis pengaruh model pembelajaran project based learning terhadap hasil belajar siswa pada mata pelajaran IPA Sekolah Dasar. *Jurnal Ilmiah Pendidikan Profesi Guru*, *3*(3), 408.

https://doi.org/10.23887/jippg.v3i3.28081

Fitriyani, A., Toto, T., & Erlin, E. (2020). Implementasi model PjBL-STEM untuk meningkatkan keterampilan berpikir tingkat tinggi. *Bioed : Jurnal Pendidikan Biologi*, *8*(2), 1-6. https://doi.org/10.25157/jpb.v8i2.4375

Hanif, M. (2020). The development and effectiveness of motion graphic animation videos to improve primary school students' sciences learning outcomes. *International Journal of Instruction*, *13*(4), 247–266. https://doi.org/10.29333/iji.2020.13416a

Khoirin, L. (2023). Pola Asuh orang tua terhadap kreativitas anak tunanetra di SLB PKK Sumberrejo. *Al-Ihath: Jurnal Bimbingan Dan Konseling Islam*, *3*(2), 190–214. https://doi.org/10.53915/jbki.v3i2.411

Kind, V. (2016). Preservice science teachers' science teaching orientations and beliefs about science. *Science Education*, *100*(1), 122–152. https://doi.org/10.1002/sce.21194

Kusmiati. (2022). Pengaruh Model pembelajaran project based learning terhadap kreativitas siswa Sekolah Dasar. *EDUCATOR : Jurnal Inovasi Tenaga Pendidik Dan Kependidikan*, *2*(2), 206–211. https://doi.org/10.51878/educator.v2i2.1309

Lestari, A. S. T., Kusumaningsih, W., & Pramasdyahsari, A. S. (2023). Analisis model pembelajaran project based learning untuk meningkatkan kreativitas dalam membuat karya dekoratif. *Didaktik: Jurnal Ilmiah PGSD FKIP Universitas Mandiri*, *09*(02), 4234–4246. https://doi.org/10.36989/didaktik.v9i2.1094

Lian, B., Kristiawan, M., & Fitriya, R. (2018). Giving creativity room to students through the friendly school's program. *International Journal of Scientific and Technology Research*, *7*(7), 1–7.

Lubis, F. A. (2018). Upaya meningkatkan kreativitas siswa melalui model project based learning. *PeTeKa*, *1*(3), 192. https://doi.org/10.31604/ptk.v1i3.192-201

Maarang, M., Khotimah, N., & Maria Lily, N. (2023). Analisis peningkatan kreativitas anak usia dini melalui pembelajaran STEAM berbasis loose parts. *Murhum : Jurnal Pendidikan Anak Usia Dini*, *4*(1), 309–320. https://doi.org/10.37985/murhum.v4i1.215

Maryani, I., Astrianti, C., & Erviana, V. Y. (2021). The effect of the STEM-PjBL model on the higher-order thinking skills of elementary school students. *Sekolah Dasar: Kajian Teori dan Praktik Pendidikan*, *30*(2), 110-122. https://doi.org/10.17977/UM009V30I22021P110

Maryani, I., Estriningrum, U., & Nuryana, Z. (2023). Self-regulated learning and creative thinking skills of elementary school students in the distance education during the COVID-19 pandemic. *Creativity Studies*, *16*(2), 496–508. https://doi.org/10.3846/cs.2023.15278

Maryanti, R., Bayu, A., Nandiyanto, D., Hufad, A., Sunardi, S., Novia, D., Husaeni, A. L., & Fitria, D. (2023). A computational bibliometric analysis of science education research using VOSviewer. *Journal of Engineering Science and Technology*, *18*(1), 301–309.

Muhanif, M., Suhartono, S., & Juhana, J. (2021). Pengaruh kedisiplinan dan kreativitas terhadap keterampilan menulis siswa sekolah dasar. *Edukatif : Jurnal Ilmu Pendidikan*, *3*(4), 1962–1973. https://doi.org/10.31004/edukatif.v3i4.1046

Nathan, R., Monk, C. T., Arlinghaus, R., Adam, T., Alós, J., Assaf, M., Baktoft, H., Beardsworth, C. E., Bertram, M. G., Bijleveld, A. I., Brodin, T., Brooks, J. L., Campos-Candela, A., Cooke, S. J., Gjelland, K. Ø., Gupte, P. R., Harel, R., Hellström, G., Jeltsch, F., … Jarić, I. (2024). Big-data approaches lead to an increased understanding of the ecology of animal movement. *Science*, *375*(6582), eabg1780. https://doi.org/10.1126/science.abg1780

Nurhaliza, P., Syafitri, Y., Usmeldi, U., & Asrizal, A. (2021). Meta analisis pengaruh penerapan STEM dalam model pembelajaran pada mata pelajaran IPA dan fisika terhadap keterampilan siswa. *Jurnal Penelitian Pembelajaran Fisika*, *7*(2), 171. https://doi.org/10.24036/jppf.v7i2.111677

Puspita, A. D., Maryani, I., & Sukma, H. H. (2023). Problem-based science learning in elementary schools: A bibliometric analysis. *Journal of Education and Learning*, *17*(2), 285–293. https://doi.org/10.11591/edulearn.v17i2.20856

Rati, N. W., Kusmaryatni, N., & Rediani, N. (2018). Model pembelajaran berbasis proyek, kreativitas, dan hasil belajar. *JPI : Jurnal Pendidikan Indonesia*, *6*(1), 60–71. https://doi.org/10.23887/jpi-undiksha.v6i1.9059

Rizkasari, Elinda, Ifa Hanifa Rahman, and Prima Trisna Aji. Penerapan model pembelajaran project-based learning untuk meningkatkan hasil belajar dan kreativitas peserta didik. *Jurnal Pendidikan Tambusai* 6.2 (2022): 14514-14520.

Rokhmaniyah, Suryandari, K. C., & Fatimah, S. (2021). Pengembangan karakter kewirausahaan peserta didik sekolah dasar melalui pendekatan STEAMS berbasis potensi lokal. *DWIJA CENDEKIA: Jurnnal Riset Pedagogik*, *5*(2), 379–387. https://doi.org/10.20961/jdc.v5i2.55865

Schneider, B., Krajcik, J., Lavonen, J., Salmela-Aro, K., Klager, C., Bradford, L., Chen, I.-C., Baker, Q., Touitou, I., Peek-Brown, D., Dezendorf, R. M., Maestrales, S., & Bartz, K. (2022). Improving science achievement—Is it possible? Evaluating the efficacy of a high school chemistry and physics project-based learning intervention. *Educational Researcher*, *51*(2), 109–121. https://doi.org/10.3102/0013189X211067742

Schutte, N. S., & Malouff, J. M. (2020). Connections between curiosity, flow and creativity. *Personality and individual differences*, *152*, 109555. https://doi.org/10.1016/j.paid.2019.109555

Sitorus, J., & Masrayati. (2016). Students' creative thinking process stages: Implementation of realistic mathematics education. *Thinking Skills and Creativity*, *22*, 111–120. https://doi.org/10.1016/j.tsc.2016.09.007

Sumaya, A., Israwaty, I., & Ilmi, N. (2021). Penerapan pendekatan STEM untuk meningkatkan hasil belajar siswa Sekolah Dasar di Kabupaten Pinrang. *Pinisi Journal of Education*, *1*(2), 217–223. https://doi.org/10.31004/irje.v2i1.272

Wahyuni, N. P. (2021). Penerapan pembelajaran berbasis STEM untuk meningkatkan hasil belajar IPA. *Journal of Education Action Research*, *5*(1), 109-117. https://doi.org/10.23887/jear.v5i1.31554

Wei, X., Weng, D., Liu, Y., & Wang, Y. (2015). Teaching based on augmented reality for a technical creative design course. *Computers & Education*, *81*, 221–234. https://doi.org/10.1016/j.compedu.2014.10.017

Widiastuti, A., Istihapsari, V., & Afriady, D. (2018). Meningkatkan kreativitas siswa melalui project-based learning pada siswa kelas V SDIT LHI. *Prosiding Pendidikan Profesi Guru Fakultas Keguruan Dan Ilmu Pendidikan*, 1430–1440.

Wulandari, A. S., Suardana, I. N., & Devi, N. L. P. L. (2019). Pengaruh model pembelajaran berbasis proyek terhadap kreativitas siswa SMP pada pembelajaran IPA. *Jurnal Pendidikan Dan Pembelajaran Sains Indonesia (JPPSI)*, *2*(1), 47. https://doi.org/10.23887/jppsi.v2i1.17222

Yarkoni, T. (2022). The generalizability crisis. *Behavioral and Brain Sciences*, *45*, e1. https://doi.org/10.1017/S0140525X20001685

Yulaikah, I., Rahayu, S., & Parlan, P. (2022). Efektivitas pembelajaran STEM dengan model PjBL terhadap kreativitas dan pemahaman konsep IPA siswa Sekolah Dasar. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *7*(6), 223. https://doi.org/10.17977/jptpp.v7i6.15275