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The Effectiveness of Project Based Learning Integrated with Deep Learning in Improving Students' Creative Thinking Skills

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A B S T R A C T

Creative thinking is required in basic biology courses, however, students' average creative thinking ability is still relatively low. This study uses a quasi-experimental research design of the posttest only control group model which aims to analyze the effectiveness of the deep learning integrated PjBL learning model to improve students' creative thinking skills in basic biology courses. The subjects of the study were the control class that produced poster products through conventional learning and the experimental class that produced video products through PjBL-Deep learning learning. Creative thinking skill data was obtained through product assessment using an assessment sheet with a likert scale of 1-4 based on 13 creative thinking indicators. The results showed that the percentage of creative thinking skills in the experimental class was in the very creative category while the control class was in the category of quite creative to creative. A statistical test using Mann-Whitney showed an Asymp value. Sig (2-Tailed) of 0.001 < 0.05 so that it was concluded that there was a significant influence of the application of the deep learning integrated PjBL model on the improvement of students' creative thinking skills in basic biology courses.

1. Introduction

In the face of the era of globalization and increasingly rapid technological development, the world of education is required to prepare human resources who have 21st century competencies and are able to adapt to dynamic changes. 21st century competencies are formulated in four main skills called the 4Cs, namely creative thinking skills, critical thinking and problem-solving skills, communication skills, and collaboration skills. Creativity is an important aspect of contextual learning , as it enables students to face competition and challenges in the 21st century more effectively. Creativity describes a more flexible mindset that can be developed through the process of problem-solving processes (Sitepu, 2019).

Not only is it a demand at the global level, but it also serves as an important indicator of students' ability to respond to technological advances, social changes, and the increasing complexity of the modern world of work. In learning biology, the ability to think creatively is very necessary to have. This is due to the characteristics of the field of biology that not only demands an understanding of facts, concepts, principles, and laws, but also includes mastery of scientific procedures (Sugandi et al., 2023). However, the fact is that students' creative thinking skills are still low. Students' critical and creative thinking skills are essential for generating innovative solutions, however based on observations to date, these abilities remain low, as many students are still unable to effectively solve problems (Wahyuni et al., 2025). This condition indicates the need for innovative learning approaches that are able to actively engage students and provide opportunities for them to develop their creative potential. From the results of the survey that has been conducted, biology learning tends to be contextual, lecturer-centered, and learning media that are not yet innovative and interesting.

To improve the 4Cs, especially creative thinking skills, it can be by developing learning models, learning media, and learning methods that are more interactive and student-centered (Indriani et al., 2023; E. H. Ramadhan & Hindun, 2023). Therefore, the development of creative thinking skills is not only an educational goal but also a necessity in preparing students to face the challenges of this modern era. There are various learning models that can be used to improve creative thinking skills, one of which is the learning model *Project Based Learning* (PjBL) (Rahman et al., 2023; Sugandi et al., 2023). This model is considered relevant because it provides students with opportunities to be actively involved in the learning process. PjBL is a learning model that has six syntax, namely problem orientation, project planning design, scheduling, monitoring project activities, testing results, and evaluation of experience. PjBL focuses on inquiry, teamwork, and authentic problem solving through contextual projects (Susilowati et al., 2026).

PjBL aims to connect theory with real-world practice, so that students do not only work on individual assignments but are involved in group projects so that they can practice planning, organizing, and completing projects together in a more structured manner. PjBL has several significant benefits, including students' creative thinking skills and learning independence (Sundari et al., 2025), increase students' activeness (Fiardilla et al., 2025), critical thinking (Sukatni et al., 2026), creative thinking, and imagination (Alifah & Abidin, 2025). These advantages indicate that PjBL is not only effective in improving cognitive aspects but also supports the development of students' overall learning skills. Although it has proven to be successful in improving creative thinking skills, in the implementation of PjBL there are still some difficulties such as not all students have the same abilities and time management. Therefore, one of the solutions to this problem is to enrich the experience in learning (Muchtar et al., 2025). To support this, a deeper understanding of the material is required so that students are not focused on completing tasks but also on understanding the concepts being learned.

Deep learning is an approach that allows for a deeper understanding of the material while connecting with the real-life context. This concept emphasizes three main

aspects, namely *mindful learning, meaningful learning,* and *joyful learning*, each of which plays a role in increasing engagement, expanding understanding, and fostering satisfaction in the student learning process. Through these aspects, students are encouraged to be more actively involved and to develop a more comprehensive understanding of the material. *Deep learning* can strengthen students' critical thinking, creativity, problem-solving, and collaboration skills (Diputera et al., 2024). By integrating the two, it can certainly be a relevant solution choice to improve students' creative thinking skills.

The development of creativity in the learning process can be achieved if the learning environment provides space for freedom of thought, tolerance for errors, and the ability to express ideas openly. Learning models that are collaborative, open, and based on authentic experiences such as PjBL are able to facilitate these conditions. When combined with an in-depth learning approach, students not only focus on completing projects, but are also invited to understand the thought flow, reflect on mistakes, and develop ideas more creatively (Nurazizah et al., 2025). This study aims to determine the effectiveness of *Project-Based Learning* and *deep learning* in basic biology courses to improve students' creative thinking skills.

2. Methodology

Research Design

The research was conducted at the University of Riau. This study is a quasi-experimental research with *a posttest only control group design*. The subjects in this study consist of two classes, namely the control class given conventional learning and the experimental class given *Project Based Learning* (PjBL) learning integrated with *deep learning*. The sample determination technique uses total sampling and the determination of control class and experimental class is carried out by random sampling. The resulting product is in the form of posters for the control class, while the experimental class is in the form of videos.

Research Instruments

The research instrument is in the form of a modified creative thinking skill assessment rubric from Putri (2019). It consists of 13 indicators in 3 aspects using a likert scale of 1-4. This rubric is used to assess the products produced by students.

Data Collection Techniques

Creative thinking skills data were obtained from the assessment of posters (control class) and video assessment (experimental class) based on creative thinking indicators referring to Besemer & Trefinger's opinion in Putri (2019) that is Novelty, Elaboration & Synthesis and Resolution. These indicators were used to evaluate students' ability to generate orginial ideas, develop and organize them systematically, and produce appropriate and relevant solutions to the given

problems. Through this assessment, students creative thinking skills can be measured in a more structured and comprehensive manner.

Data Analysis Techniques

Data analysis is carried out through two stages, namely descriptive analysis and inferential analysis. Descriptive analysis is used to describe the level of students' creative thinking skills. The assessment of creative thinking skills is calculated with the following formula:

$$\text{Percentage Score} = \frac{Skor\ Diperoleh}{Skor\ Maksimum}\ x\ 100\%$$

Furthermore, the percentage that has been obtained is interpreted using categories. The category of creative thinking is guided by Devi et al., (2019), as presented in Table 1.

Table 1. Creative Level Category

Interval	Category
80 - 100	Very Creative
60 – 79	Creative
40 – 59	Quite Creative
20 – 39	Less Creative
0 - 19	Very Less Creative

(Devi et al., 2019)

Meanwhile, inferential analysis was carried out through the Mann-Whitney U Test using SPSS to determine the difference in creative thinking skills between the control class and the experimental class.

3. Results and Discussion

The Project Based Learning *learning model* integrated with *deep learning* in the experimental class is carried out through a series of PjBL syntax, namely problem orientation; designing project planning, in this case, video; compiling schedules; monitoring project activities; testing results; and evaluating experience. Each stage in the PjBL syntax plays a crucial role in fostering students' creative thinking skills. At the orientation stage, problems relevant to daily life are presented to stimulate students' curiosity and encourage them to identify and understand real-world issues. This stage is important in activating prior knowledge and preparing students to engage in deeper learning. Next, the design stage of project planning is the creation of videos as the final product, as well as compiling the workflow. This process allows students to develop their ability to plan, organize ideas, and think creatively in determining how concepts will be presented. The schedules stage, students will be manage their time effectively and develop responsibility for completing tasks within a given timeframe. Meanwhile, during this process, lecturers act as facilitators and monitor the progress of the project as well as provide feedback. This

feedback plays an important role in helping students refine ideas and improve the quality of their work.

The testing and evaluation stages allow students to assess the results of their projects and reflect on their learning experiences. Through reflection, students are able to identify strengths and weaknesses in their work, which contributes to the development of higher-order thinking skills. Students are facilitated through Pjbl-deep learning Student Worksheets, which guide them in completing each stage of the project. These worksheet are designed to facilitate creavitve thinking skill. As shown in figure 1, the figure presents several excerpts from the worksheets, including the cover and selected sections of the content that reflect the structure of learning activities in this study.

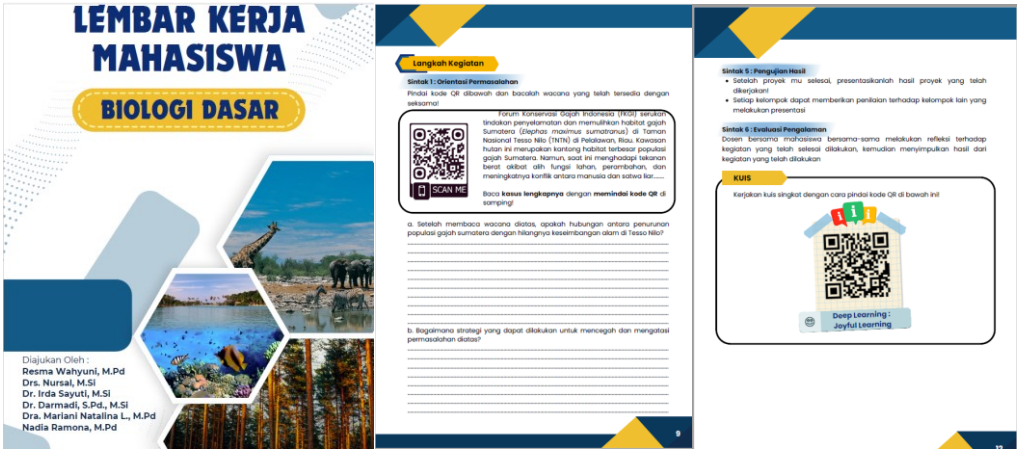

Figure 1. PJBL- and Deep Learning Students' Work Sheet

Not only project-based learning, but there is also an approach *deep learning*. *Deep learning* emphasizing deep learning, not just surface understanding. Students are encouraged to think at a high level. *Deep learning* focusing on efforts to build a more comprehensive understanding of the material through a complete learning experience (Nurul et al., 2025). It is implemented through three main components, namely *mindful learning, meaningful learning,* and *joyful learning* (Devi et al., 2019). *Mindful learning* Focus on full awareness in learning activities (Mustafa et al., 2025). *Meaningful learning* is, students are able to connect new concepts with knowledge that they have previously possessed so that meaningful learning is created. While *joyful learning* emphasizing the creation of a learning process that is fun, comfortable, and able to foster learning motivation (Syafi'i & Darnanengsih, 2025).

The integration of PjBL with deep learning creates a more holistic learning experience. While PjBL emphasizes active participation through project creation, deep learning ensures that student' not only complete tasks but also understand the underlying concepts in depth. This combination supports students in developing not only cognitive skills but also metacognitive awareness, where they are able to reflect on their own learning processes. Students in the experimental class were

actively involved and creative during the learning compared to the control class. To find out if there is a significant difference, the Mann-Whitney test is performed.

As shown in table 2 below, the Mann-Whitney test shows a comparison between the control class group and the experimental class group on creative thinking skills in basic biology learning. Based on the test, it is known that the Asymp. Sig (2-tailed) is 0.001 < 0.05, then H0 is rejected and H1 is accepted. This means that the learning of the *Project Based Learning* model integrated *with deep learning* has a significant effect on improving students' creative thinking skills in basic biology courses. In addition, the magnitude of the difference between the two groups indicates that the implemented learning model does not only produce statistically significant results but also has has a substantial practical impact on students creatice thinking skills.

Table 2. The Mann-Whitney Test

Test Statistics

	Creative Thinking
Mann-Whitney U	,000
Wilcoxon W	36,000
Z	-3,391
Asymp. Sig. (2-tailed)	,001
Exact Sig. [2*(1-tailed Sig.)]	,000b

a. Grouping Variable: class
b. Not corrected for ties.

The results of students' creative thinking skills were obtained from the results of posttests in the form of products, namely posters and videos. These products were designed to reflect students' understanding of basic biological concepts as well as their ability to express ideas creatively. Through these product, students were given the opportunity to express their ideas more freely and innovatively. The results can be seen in the following table 3.

Table 3. Percentage of Students' Creative Thinking Skills in the Control Class and the Experimental Class

Group	**Percentage**			
	Control Class	**Category**	**Experimental Classes**	**Category**
Group 1	65,38	Creative	94,23	Very creative
Group 2	42,31	Quite creative	90,38	Very creative
Group 3	75,00	Creative	94,23	Very creative
Group 4	73,08	Creative	94,23	Very creative
Group 5	50,00	Quite creative	86,54	Very creative
Group 6	75,00	Creative	96,15	Very creative
Group 7	48,08	Quite creative	90,38	Very creative
Group 8	57,69	Quite creative	94,23	Very creative

Based on table 3, it is known that the score percentage range from the control class is 42.31-75.00 with the category of quite creative to the creative category. Meanwhile, the experimental class has a score percentage range of 86.54-96.15 with a very creative category in all groups. This shows that there is a significant

difference. This consistency indicates that the applied learning model does not only benefit certain groups but has a uniform impact across all students. Meanwhile, the control class shows more varied results, this suggesting that conventional learning dose not equally support the development of creative thinking skills among students. In line with research Wulandari & Wibawa., (2021) Use of learning models *Project Based Learning* Based *Deep Learning* can improve creative thinking skills. Project based activities encourage students to explore multiple solutions, think divergently, and produce original ideas to solve the cases presented in the worksheets.

In conventional learning, the delivery of material tends to be one-way so that it seems to limit students to explore their ideas and develop higher-order thinking skills. Unlike conventional learning, in project-based deep learning, students are able to generate a variety of ideas and can develop and mature these ideas into a real work (Nurazizah et al., 2025). This certainly trains students' creativity in the learning process so that learning is no longer lecturer-centered, but student-centered (*student centered)*. Students can play an active role through group discussion and collaboration activities. In the experimental class, students are given the opportunity to explore basic biological concepts in more depth through a series of project activities. This process is the difference from the control class, where learning still tends to be centered on the lecturer. The application of a learning model that requires active involvement through discussion activities and group work helps students to be disciplined, able to work together, and able to improve their creative thinking skills (Altatri & Ardi, 2024).

Deep learning can improve students' skills in solving problems creatively by connecting their knowledge with new information. Through *Deep Learning* most important *mindful learning* Students can further increase self-awareness, concentration, creativity, and collaboration so that they are fully actively involved in the learning process (Azzahra & Jaya, 2025; Fatihah et al., 2025; A. Ramadhan, 2025). The use of learning media is also an effective alternative to support the project-based deep learning process. This is also in line with research Hendarto *et al*., (2025), learning media are able to provide an interesting learning experience and facilitate independent learning so that independence is created in exploring concepts to strengthen creative and reflective thinking skills. The findings of this study have important implications for educators, particculary in higher education. Lecturer are encouraged to adopt innovative learning models such as PjBL integrated with deep learning to create more engaging and meaningful learning experiences that support the development of 21st century skills. The role of the lecturer as a facilitator is also a key factor in he success of this learning model, as continuous guidance and feedback help students refine their ideas and improve the quality of their work.

4. Conclusion

Overall, the results of the study showed that the creative thinking skills of students in the experimental class were higher than those in the control class. All groups in

the experimental class showed a category of "very creative", while the control class had a varied category, ranging from "quite creative" to "creative". This difference is supported by the results of statistical tests that show significant differences between the two classes. This confirms that active involvement in project-based deep learning contributes positively to students' creative thinking skills. Thus, the application of *Project Based Learning* integrated with *deep learning* can have a positive impact on improving students' creative thinking skills in basic biology learning.

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