



Integrating Scratch with Project-Based Learning to Cultivate Students' Academic Performance

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Abstract: This study addresses the challenge of enhancing students' academic performance, including creativity, learning achievement, problem-solving ability, motivation, and attitude, by integrating problem-solving into biology lessons through Scratch and Project-based Learning (PjBL). The focus was on high school students studying the digestive system, a topic often taught through traditional lecture-based methods, which can limit engagement and deeper understanding. A quasi-experimental design with a nonequivalent control group pretest-posttest was employed, involving 105 eleventh-grade students divided into three groups: PjBL with Scratch, PjBL without Scratch, and a control group receiving direct instruction (DI). The same teacher taught all groups to ensure consistency. Research instruments included cognitive tests, problem-solving assessments, and questionnaires measuring creativity, motivation, and attitudes toward biology and programming. Results indicated that PjBL with the Scratch group significantly outperformed the other two groups in all aspects, demonstrating improved learning outcomes and a greater ability to apply knowledge in creative and meaningful ways. Students expressed higher motivation and more positive attitudes toward the subject matter. This study concludes that integrating Scratch with PjBL enriches biology education and enhances interdisciplinary learning. The findings contribute to educational science by offering a scalable, innovative model that bridges STEM fields and fosters critical 21st-century skills.

Keywords: academic performance, digestive system, direct instruction, project-based learning

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INTRODUCTION

Computer programming knowledge and skills are acknowledged as a crucial and demanding task in the present-day educational landscape. This activity can enhance students' problem-solving capabilities alongside developing proficiency in programming language syntax, technical skills, and academic performance. One of the learning tools that provides students with these skills is Scratch (Hwang et al., 2008; Tarigan et al., 2024). Scratch, a visual programming language, offers numerous benefits for science learning, such as engagement and exploration through a hands-on, interactive platform for students to create and experiment with science-related projects. Students can engage actively with scientific concepts by coding and creating simulations, fostering more profound understanding and curiosity. It engages students' problem-solving skills by designing them to design Scratch projects, break down tasks, and iteratively refine their solutions (Schwartz et al., 2024). This allows students to visualize abstract scientific concepts through animations, simulations, and interactive models (Procopio et al., 2024). Students can share and remix projects, which promotes peer learning and communication. They can collaborate on science-related projects, share their ideas, and receive feedback, which enhances communication and collaboration skills (García, 2023). Through coding, students can explore innovative problem-solving approaches and create novel solutions, fostering creativity and innovation in science learning (Brennan & Resnick, 2012; Piedade & Dorotea, 2022). Academic performance is a multifaceted aspect of student behavior influenced by various factors, including memory, prior knowledge, aptitude, and psychological aspects (Spalek, 2014). It has become a significant concern for researchers, especially in university settings (Van Tassel-Baska & Stambugh, 2006). Educators, trainers, and researchers are keen on identifying variables significantly impacting learners' performance, such as creativity, learning attitude, motivation, and achievement (Queiruga-Dios et al., 2021). Academic performance encompasses the assessment of a student's proficiency across a range of academic domains. Teachers and education administrators often rely on indicators like classroom performance, graduation rates, and standardized test results to gauge student achievement (Schneider et al., 2022).

According to Research by Innovation and Science Australia (ISA), in 2017, 92% of future occupations will require digital skills. The government must adapt to the evolving workforce by providing all Australians with skills relevant to the 2030 job market (Australian Government, 2017). Human civilization relies heavily on digital abilities, making computer education increasingly important. Since 2012, Estonia's Proge Tiger initiative has

integrated programming and STEAM courses into the national curriculum, equipping students with future-ready skills (Education Estonia, 2021). Similarly, the United Kingdom's 2014 National Curriculum mandates coding and computer education through a four-stage computation curriculum to develop digitally literate and proficient pupils (Wong et al., 2015). Clearly, computing education is increasingly prioritized worldwide and will be a cornerstone of future basic education curricula. Indonesia reflects this trend with its 2021 Secondary Education Curriculum Guidelines, emphasizing information literacy within the technology domain (UNICEF Indonesia, 2021).

The Merdeka Curriculum mandates a more active role for students than instructors, as active engagement promotes students' creativity through PjBL (UNICEF Indonesia, 2021). Grounded in constructivist theory, PjBL offers abundant opportunities for students to create dynamic and engaging learning environments (Isabekov & Sadyrova, 2018). Furthermore, it shifts the focus of conventional learning from reading, writing, and arithmetic to developing academic literacy through doing, using, and thinking (Yadav et al., 2016). It governs the learning process through project activities that develop students' learning attitudes, achievements, and problem-solving skills via group discussion. This learning technique allows students to work for a defined period before producing a product and delivering a presentation (Isabekov & Sadyrova, 2018). In PjBL, students engage in exploration, assessment, intervention, synthesis, and information to produce diverse learning outcomes, promoting creativity (Hastuti et al., 2023). PjBL guides teachers in designing projects and implementing standards-aligned tasks that engage students. This approach promotes the development of domain knowledge and problem-solving abilities through collaborative teamwork, effective communication, and critical thinking (Husna et al., 2024). PjBL offers students the chance to investigate issues, make decisions, and develop solutions, thereby fostering crucial 21st-century skills such as critical thinking, collaboration, communication, creativity, innovation, self-direction, global awareness, and local connections, and technological literacy (Miller & Krajcik, 2019).

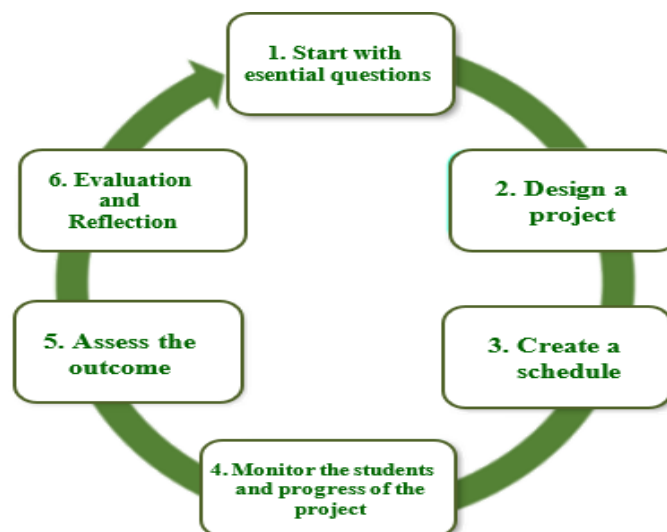


Figure 1. Phase of Project Based Learning (Lucas, 2005)

PjBL has been widely adopted across diverse educational settings and has demonstrated effectiveness in enhancing student learning outcomes. Research has explored its impact on interdisciplinary learning, revealing significant improvements in students' self-efficacy (Wu et al., 2021). Moreover, a study proposed that a project-based digital storytelling approach has increased student motivation, achievement, and problem-solving skills, showing greater effectiveness than traditional learning methods. The widespread availability of the Internet has provided students with ample resources to access knowledge. Numerous project-based learning initiatives involve students in gathering data from the web-based data to explore specific topics (Çiftçi & Baykan, 2013). However, the effectiveness of PjBL activities in improving students' learning outcomes and motivation continues to be a challenge. Integrating internet-based data collection and synthesis within a PBL framework can foster higher-order thinking skills in students, including computer programming (Hung et al., 2012).

Regarding instructional methods, many teachers typically present learning materials to students as separate, standalone modules. Moreover, a strong emphasis on explaining programming commands and syntax often hinders students' ability to apply programming skills effectively in problem-solving contexts (Hidayat et al., 2024). Previous research has indicated that design, as a structured problem-solving process, should actively involve learners in addressing challenges while applying their knowledge and skills. To achieve this, the study suggests an integrated approach that combines Scratch with Project-Based Learning (PjBL) (Taylor et al., 2010). This approach integrates programming fundamental computer constructs, applications, and programming units

with problem-solving strategies within a PjBL framework.

According to an interview with the teachers, most teachers employ a direct instructional approach. This method tends to disengage students, limiting their active participation in the learning process (Hidayat et al., 2024). Students who are not given direct experience in the learning process are less likely to develop as creative learners. They become weary of the same learning regimen and absorb what the instructor says with minimal input from other sources. This approach does not foster information sharing with their peers (Rivadeneira & Toledo, 2024). Conventional learning methods often fail to stimulate students' learning interests, making it more challenging to achieve high learning outcomes (Preliminary Research, 2023). Direct instructional methods typically place the teacher in the central role as the primary source of knowledge and authority in the classroom (Tarigan et al., 2023). This can limit opportunities for student-led inquiry, collaboration, and peer learning, which are important for developing independent learners and critical thinkers (Rahmatullah et al., 2022; Tarigan et al., 2021).

Some schools in Asia use plugged activities to teach technology implementation in science. Scratch allows users to stack instructions by dragging and dropping (Marcelino et al., 2018). This approach helps students develop creativity and understand computational thinking principles (Marcelino et al., 2018; Papadakis & Kalogiannakis, 2019). Conversely, unplugged teaching, which does not require a computer, can be conducted using paper, pens, and simple teaching materials. This method is advantageous for instructors and students who lack access to the necessary computer equipment for computing instruction (Papadakis et al., 2017; Papadakis & Kalogiannakis, 2019). Previous research has suggested that students develop more complex and organized knowledge structures based on their learning experiences. Additionally, separate findings indicated that students could independently acquire fundamental computer knowledge with appropriate, effective learning support (Grover & Pea, 2018; Kuo & Hsu, 2020; Ridlo et al., 2022).

Rooted in Dewey's concept of "learning by doing," PjBL is distinguished by its student-centered approach, which enhances learning outcomes through various educational tasks (Isabekov & Sadyrova, 2018). Throughout the PjBL process, students gather information for assigned tasks and actively employ their acquired knowledge to explore, interpret, create, and construct new understandings (Hastuti et al., 2023). As Husna et al. (2024) highlight, PjBL has the potential to nurture 21st-century skills among students, such as creativity, problem-solving, and learning achievement. It is particularly effective in enhancing learning achievement in science education. Implementing PjBL can vary and requires careful consideration of student preferences and project feasibility. Projects must be meticulously planned, managed, and evaluated to cultivate academic performance effectively. This study aims to deepen educators' understanding of the effectiveness of integrating PjBL with Scratch in science education, especially in biology, to facilitate enhancing academic performance among students.

This research primarily investigates the impact of integrating Project-Based Learning (PjBL) with Scratch on human digestive topics for secondary students. A detailed discussion and elaboration based on the collected data will be presented. This study presents an integrated approach combining Scratch and PjBL, incorporating problem-solving strategies within the PjBL framework. A PjBL activity was implemented in a biology course to evaluate this approach's effects on various students. Specifically, this study sought to determine whether the integrated Scratch and PjBL approach enhances student creativity. Additionally, it aimed to investigate whether this integration is advantageous for improving academic performance, including students' learning achievement. Another focus of the study was to examine the contribution of the integrated Scratch and PjBL to developing students' problem-solving skills. The research also explored whether this approach positively influences students' learning motivation and attitudes.

METHODS

This research employed a quantitative approach utilizing a quasi-experimental design, specifically a nonequivalent control group framework (Philippakos et al., 2021). A total of 105 eleventh-grade students participated in the study, distributed across three classes: 35 students in the plugged class (PjBL with Scratch), 35 students in the unplugged class (PjBL without Scratch), and 35 students in the direct instructional learning without Scratch. All three classes were taught by the same teacher. This study comprised six learning sessions, each lasting 90 minutes. Students were randomly grouped into teams of five throughout the learning process. Prior to the sessions, an assessment was conducted in all classes to gauge students' computer proficiency. The survey results indicated that most students were proficient in using computer-based learning tools. Data on students' creativity, learning achievement about digestive system topics, problem-solving ability, motivation, and attitudes were collected before and after the learning activity.

An integrated approach combining Scratch and Project-Based Learning (PjBL) was proposed to design a scenario related to the digestive system, involving interactive activities by developing suitable coding to create animations. At the beginning of the learning activity, all students explored the organs of the digestive system

using online resources. Students applied their knowledge to collaboratively create a digital animation in teams using the Scratch programming tool. Scratch is a visual programming language designed to enable young learners to create interactive stories, games, animations, and simulations. This platform offered diverse avenues for students to nurture their creativity, logical reasoning, and reflective skills throughout the learning journey (Brennan & Resnick, 2012; Piedade & Dorotea, 2022).

In the Project-Based Learning (PjBL) classes, the emphasis is on hands-on activities such as poster creation and model building related to the digestive system (unplugged activities). Students do not utilize Scratch or other internet-based tools in this process. Instead of relying on digital resources, teachers introduce the digestive system through brief group presentations. Following these introductions, students independently develop projects centered on the topic without incorporating Scratch. Students collaborate within groups to conceptualize their project designs. The direct instructional (DI) class followed a traditional teaching approach, where students received lectures, participated in guided learning, and completed textbook-based assignments without engaging in hands-on projects or digital tools. In this setting, the teacher delivered structured content on the digestive system through PowerPoint presentations and printed handouts, with limited opportunities for interactive exploration.

Assessments in this group primarily focused on factual recall and comprehension through quizzes and written tests. While the DI model ensured content coverage, it provided fewer opportunities for students to develop critical thinking and collaborative skills than the PjBL classes. This contrast allowed the study to examine the varying impacts of project-based, technology-enhanced, and traditional instructional methods on students' overall engagement and learning outcomes. A detailed comparison of the learning phases across both PjBL (with and without Scratch) and Direct Instruction (DI) Learning without Scratch (Joyce et al., 1996) classes is presented in Table 1.

Table 1. Learning Phases in PjBL and DI Classes

Plugged Learning		Unplugged Learning Without Scratch
Project Based Learning (PjBL) Integrated Scratch	Project Based Learning (PjBL)	Direct Instructional Learning (DI)
<i>Start with the essential questions</i>		<i>Orientation</i>
Students identify the learning objectives, select a real-world problem, and find a problem-solving strategy by introducing Scratch as the learning tool.	Students identify the learning objectives and select a real-world problem that will engage them.	The teacher introduces the material to the students by prompting them to recall their prior knowledge or understanding.
<i>Designing a project</i>		<i>Presentation</i>
The teacher asks the students to write the programming introduction concepts acquired from the web.	The teacher asks the students to design the project, including its scope and resources needed.	The teacher explains the new material through lecture learning.
<i>Create a schedule</i>		<i>Structured Practice</i>
The teacher set the schedule/timeline for finishing the project.		The teacher guides students through the exercises, providing feedback on their responses, reinforcing correct answers, and correcting any mistakes.
<i>Monitoring the Project's Progress</i>		<i>Guided Practice</i>
Students use the Scratch software to develop the digital story based on the plot and the flowchart for designing the animations or videos by using Scratch.	Students actively engage in project activities, which may include conducting research related to the project and collaborating with peers.	Teachers offer opportunities for students to practice concepts and skills while monitoring their progress and guiding them as they complete the tasks.
<i>Assess the outcome</i>		<i>Independent Practice</i>
Teachers use Scratch to assess students' ability to collaborate, think critically, and apply knowledge and skills to create the product. They also evaluate the quality of the final product.	Teachers assess students' ability to collaborate, think critically, and apply knowledge and skills to solve problems. They also evaluate the quality of the final product.	Students perform practice activities independently. They advance to the next phase if they have successfully completed 80%-90% of the assignments in the practice guidance phase.
<i>Evaluation</i>		
Students reflect on their learning experiences using Scratch, evaluate their own progress, and consider how they can apply what they have learned in the future.	Students reflect on their learning experiences, evaluate their own progress, and consider how they can apply what they have learned in the future.	

After completing the learning activity, the DI, PjBL plugged, and PjBL unplugged groups took a posttest. This assessment included measures of problem-solving skills and post-questionnaires to evaluate creativity, learning motivation, and attitudes to assess their learning outcomes and perceptions. All classes utilized the printed digestive learning module developed by Tarigan et al. (2021, 2023) in alignment with current research needs. The DI model comprises several stages, namely learning orientation. During this phase, the teacher introduces the lesson by explicating content from the printed digestive system module, while stimulating students to recall prior knowledge about the subject matter. Following this, the teacher delivers explanations, provides examples, administers tests to measure comprehension, and assigns homework to facilitate independent learning. Notably, students do not engage in project creation, and the primary knowledge sources for students are the teacher's instruction and the digestive system module.

The assessment tools utilized in this study encompassed evaluations of learning achievement and problem-solving ability, along with questionnaires designed to gather data on creativity, learning motivation, and attitudes toward biology lessons and learning tools. The pretest and posttest consisted of twenty-five multiple-choice items assessing learning achievement, each with four options, and were validated by an expert, yielding a Cronbach's α value of 0.83. The pretest was administered to assess student's prior knowledge before the learning activity, while the posttest evaluated their learning outcomes following the activity. Each test scored out of a maximum score of 100 points. The creativity questionnaire comprised ten items utilizing a five-point scale adapted from (Rhodes, 1961) and demonstrated a Cronbach's α value of 0.80. The research model for this study is shown in Figure 2.

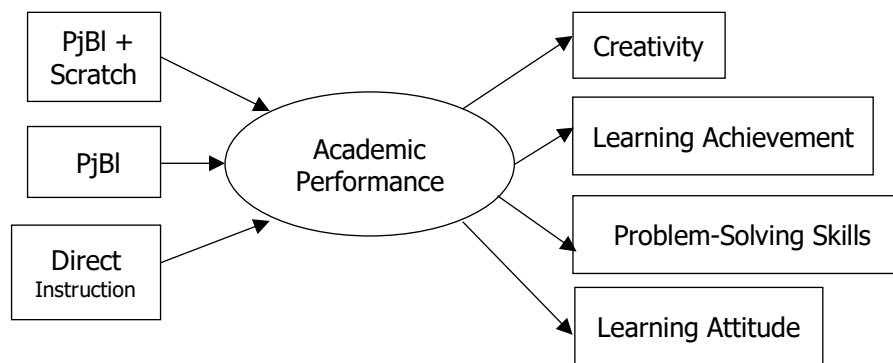


Figure 2. Research Treatment and Variables

The learning attitude questionnaire comprised ten items, five related to biology lessons and five to learning tools, each with four response options. This questionnaire was adapted from the TIMSS 2019 Context Questionnaire Framework (Japelj Pavešić et al., 2022; Martin & Mullis, 2019) and demonstrated reliability values of 0.82 for both sections. The problem-solving assessment was done through a questionnaire adapted from Kusumah et al. (2021), with a reliability value of 0.637. The learning motivation questionnaire included ten items modified from a measure Bin Dayel et al. (2018) used with a reliability value of 0.85. These reliability values for the adopted assessments and questionnaires indicate high internal consistency. The research data were analyzed using an ANOVA test with the SPSS application.

RESULT AND DISCUSSION

One aim of this study was to examine the improvement in students' creativity following the learning experience in the Scratch-oriented PjBL and PjBL without Scratch as the experimental class and the DI model as the control class. The paired sample t-test results (pre- & posttest) for student creativity, as shown in Table 2, reveal a significant difference ($p < .05$). This indicates that students made substantial progress following the learning activity.

Table 2. Paired t-test of creativity (* $p < 0.05$)

		N	Mean	SD	<i>t</i>
Creativity	Pretest	105	57.16	6.47	0.00*
	Posttest	105	82.80	8.37	

The adjusted mean posttest creativity scores indicate that the PjBL approach, integrated with Scratch, significantly outperformed the other methods, as presented in Figure 3. The creativity pretest and posttest scores of all groups were analyzed using ANOVA. Initially, the homogeneity of pretest scores across all classes was assessed, yielding $F = 0.18$, $p > .05$, indicating that students across all classes had similar initial levels of creativity.

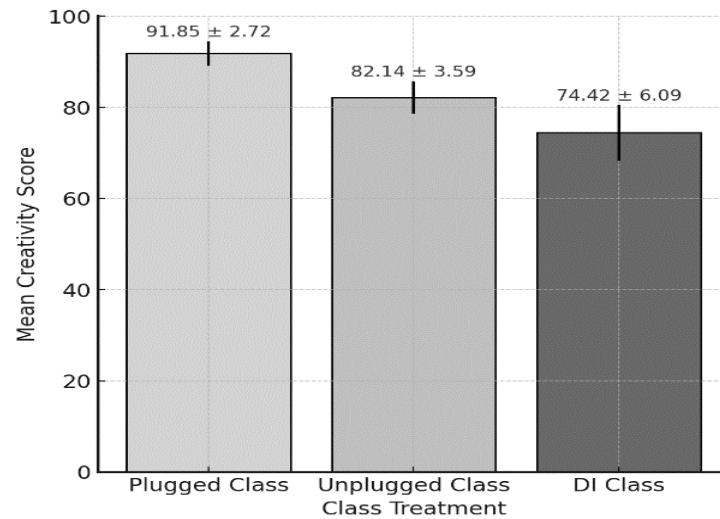


Figure 3. Creativity Scores Across Different Class Treatment

The p-values from the normality tests for each class were greater than .05, suggesting comparable baseline creativity among students in each class. Subsequently, ANOVA was conducted using the pretest scores as covariates to control for initial differences among the samples, with a significant difference of 0.00 ($p < .05$). The second objective of this study was to examine improvements in students' learning achievement after exposure to different learning environments. The results of the paired-sample t-test for learning achievement, presented in Table 3, show a significant difference ($p < .05$). This indicates that all students made substantial progress following the learning activity.

Table 3. Paired sample t-test result of learning achievement (* $p < 0.05$)

		N	Mean	SD	t
Learning Achievement	Pretest	105	51.87	2.65	0.001*
	Posttest	105	82.80	8.37	

The learning achievement scores from pretest and posttest were analyzed using a paired t-test. First, the homogeneity of pretest scores between the plugged and unplugged classes was assessed with $F=0.15$, $p > .05$, indicating that students had similar prior cognitive achievement. The p-values from the normality tests for each class were greater than .05, suggesting comparable baseline learning achievement among students in each class. Subsequently, ANOVA was used to analyze and adjust for differences in the samples. The results show a significant difference between the experimental and control groups ($p < .05$), indicating that the plugged class significantly outperformed the others. The mean posttest learning achievement scores are presented in Figure 4.

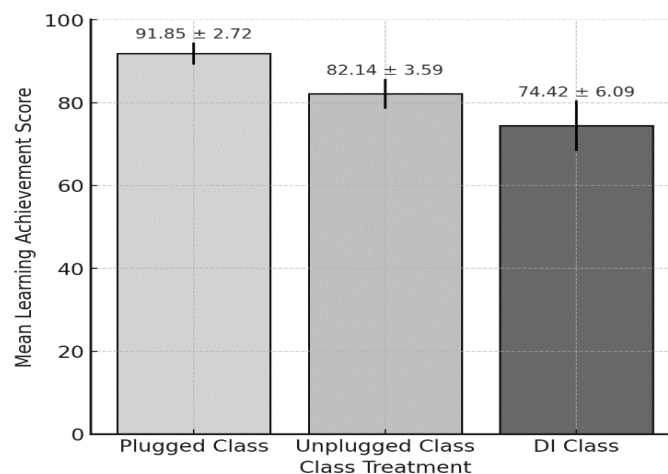


Figure 4. Learning Achievement Scores Across Different Class Treatment

A paired-sample t-test was conducted to evaluate students' problem-solving skills after implementing the proposed learning approach and to compare their performance before and after the learning activity. The statistical results presented in Table 4 show a significant improvement in problem-solving ability ($p < .05$).

Table 4. Paired sample t-test result of problem-solving skills (* $p < 0.05$)

		N	Mean	SD	t
Problem-Solving Skills	Pretest	105	49.90	8.16	0.00*
	Posttest	105	83.20	8.86	

ANOVA was then used to compare the pre- and post-questionnaire ratings of problem-solving ability among the PjBL plugged, PjBL unplugged, and control classes (DI). The test for regression homogeneity indicated homogeneity of problem-solving skills, with $F = 0.17$, $p > .05$. The p-values from the normality tests for each class were greater than .05, suggesting comparable baseline problem-solving skills among students in each class. A significant difference was found between the three groups ($p < .05$), indicating that the proposed approach's intervention could improve the plugged group's problem-solving ability. The mean posttest problem-solving scores are presented in Figure 5.

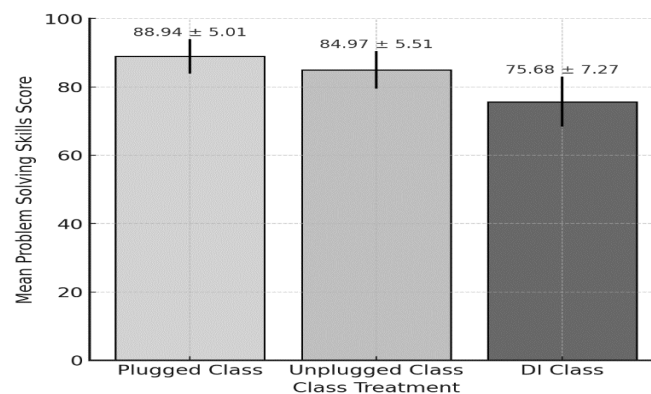


Figure 5. Problem-Solving Skills Scores Across Different Class Treatment

A paired-sample t-test was conducted to evaluate students' learning motivation by analyzing pre- and post-questionnaire ratings, as shown in Table 5. The statistical results indicate a significant increase in students' learning motivation after the learning activity ($p < .05$), suggesting that the proposed learning approach effectively enhanced their motivation.

Table 5. Paired sample t-test result of learning motivation (* $p < 0.05$)

		N	Mean	SD	t
Learning Motivation	Pretest	105	52.52	7.56	0.00*
	Posttest	105	86.04	5.98	

ANOVA was further used to compare the post-questionnaire ratings of learning motivation between the experimental and control groups while accounting for the influence of pre-questionnaire ratings. The test for homogeneity of pre-questionnaire ratings showed consistency across all groups, with $F = 0.184$ ($p > .05$).

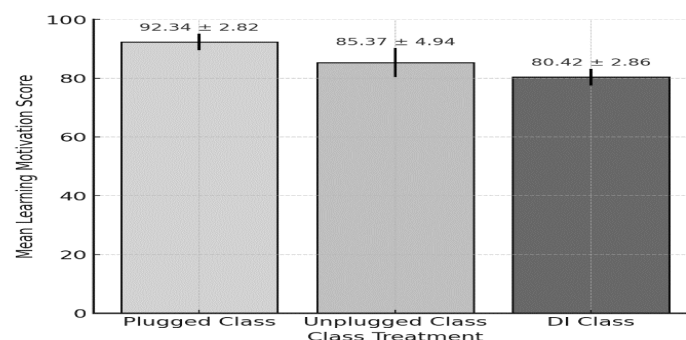


Figure 6. Learning Motivation Scores Across Class Treatment

The p-values from the normality tests of learning motivation for each class were greater than .05, indicating comparable baseline learning motivation among students in each class. It suggests that ANOVA is appropriate for analyzing the post-questionnaire ratings of all groups. The result indicates that the proposed learning approach positively impacted learning motivation across the groups. The mean posttest learning motivation scores are presented in Figure 6. A paired-sample t-test was conducted to assess students' learning attitudes by analyzing pre- and post-questionnaire ratings, as shown in Table 6. The statistical results show a significant improvement in students' learning attitudes after the learning activity ($p < .05$), indicating that the proposed learning approach effectively enhanced their attitudes toward learning.

Table 6. Paired sample t-test result of the student's learning attitude (* $p < 0.05$)

Attitude		N	Mean	SD	T
Biology Learning	Pretest	105	61.39	4.97	0.00*
	Posttest	105	86.98	6.83	
Learning Tools	Pretest	105	60.80	6.05	0.00*
	Posttest	105	86.27	6.75	

ANOVA was further employed to compare the post-questionnaire ratings of learning attitudes between the experimental and control groups, controlling for the impact of pre-questionnaire ratings. The test for homogeneity of pre-questionnaire ratings showed consistency across the groups, with $F = 0.186$ ($p > .05$); the p-values from the normality tests for each class were greater than .05, indicating comparable baseline learning attitudes among students in each class. ANOVA is suitable for analyzing the post-questionnaire ratings. ANOVA results suggest that the proposed approach improved students' attitudes toward the course and their use of learning tools to organize content while studying in class.

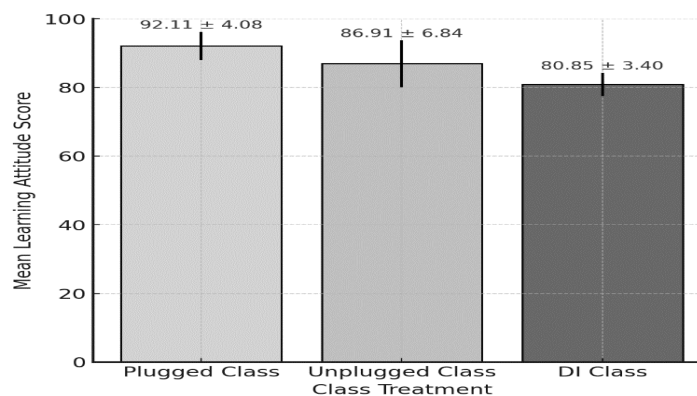


Figure 7. Learning Attitude Scores Across Class Treatment

The findings of the study reveal that the Scratch-oriented PBL significantly enhanced all students' learning outcomes, aligning with previous research (Hung et al., 2012; Karakaya Cirit & Aydemir, 2023; Schaffer et al., 2012). Similarly, both learning attitude toward biology lessons and attitude toward using learning tools are revealed to have significantly positive agreement in the study, which is compatible with previous research findings by Tanrikulu and Schaefer (2011) & Wibowo et al. (2024). These results suggest that Scratch's graphical interface provides an accessible and engaging programming environment, fostering positive learning attitudes. Studies by Hastuti et al. (2023) and Solier and Soto (2024) indicate that students participating in technology-integrated PjBL exhibit significantly enhanced creative thinking compared to traditional learning. Moreover, Scratch programming in PjBL has been shown to facilitate exploration, experimentation, and innovation, fostering a conducive environment for creativity development (Miller & Krajcik, 2019; Stockard, 2021). Scratch's interactive platform facilitates hands-on learning, encouraging exploration, experimentation, and innovation, essential components of creative thinking (Pellas, 2024).

Direct instructional methods often prioritize rote memorization and recall of facts over critical thinking and problem-solving. This approach can encourage students to focus on memorizing information for assessments rather than developing a deep understanding of concepts or applying knowledge to real-world contexts (Hastuti et al., 2023; Isabekov & Sadyrova, 2018; Miller & Krajcik, 2019; Stockard, 2021). Scratch's interactive and creative nature fosters active student engagement, boosting interest, motivation, and learning achievement (Yu et al., 2024). PjBL often involves student collaborative work, promoting teamwork, communication, and interpersonal skills. By working together on Scratch projects, students learn from each

other, share ideas, and collaborate to solve problems, leading to mastery of biology concepts (Wang et al., 2014). Scratch-oriented PjBL activities allow students to develop digital literacy skills, enhancing their academic performance and future career prospects (Kim & Song, 2012; Peppler & Kafai, 2007).

On the other hand, the direct instructional model often relies on teacher-centered instruction, where students passively receive information through lectures or demonstrations. This can lead to limited student engagement, as learners may become disinterested or disengaged when not actively involved in the learning process. Direct instructional approaches often limit students' autonomy and ownership of their learning. Students may have little input in the learning process, leading to a lack of motivation, engagement, and ownership over their education. According to scholars, the Project-Based Learning (PjBL) approach, a student-centered learning model, engages students in applying their acquired knowledge and experience to new tasks. It encourages them to explore, create, and construct new knowledge (Hastuti et al., 2023; Isabekov & Sadyrova, 2018; Miller & Krajcik, 2019; Tamim & Grant, 2013).

Scratch programming inherently involves problem-solving as students work through coding challenges and debug their programs. By participating in these activities, students develop critical thinking and problem-solving skills essential for academic success across various subjects. In contrast, traditional direct instruction often employs a one-size-fits-all approach, delivering content uniformly to all students. This can overlook individual differences in learning styles, interests, and prior knowledge, potentially leaving some students disengaged or academically (Liem & Martin, 2013). Regarding the impact on problem-solving ability, the statistical results showed a significant improvement in students' performance. The proposed learning approach allowed students to collaborate with peers on tasks, necessitating applying their knowledge and experience to explore resources and solve problems (Barron et al., 1998; Husna et al., 2024; Karyadi et al., 2020). Additionally, students could enhance their creative and reflective thinking skills through problem-solving processes using the Scratch programming tool (Peppler & Kafai, 2007; Piedade & Dorotea, 2022; Tanrikulu & Schaefer, 2011).

Scratch programming empowers students to express their creativity and imagination through coding. Students can explore and experiment with diverse ideas by designing animations, games, and stories, fostering a sense of creativity and innovation that can enhance their motivation to learn. Gamification Scratch incorporates gamification elements, such as earning badges, completing challenges, and receiving feedback, making learning more enjoyable and engaging for students. These gamification elements can incentivize students to actively participate in PjBL activities and strive to achieve their learning goals (Wang et al., 2014). Completing Scratch projects and seeing their creations come to life can give students a sense of accomplishment and satisfaction.

Scratch's immediate feedback loop, where students can observe the real-time effects of their code, reinforces their competence and progress, thereby increasing motivation to learn and explore new concepts. Additionally, collaborative project work fosters community and belonging, enhancing students' overall motivation (Hastuti et al., 2023). PjBL Scratch activities can be customized to fit students' interests, preferences, and learning objectives. Students who work on projects that resonate with their interests or tackle real-world issues are more likely to be motivated and actively engaged in their learning. Integrated PjBL with Scratch supports students to take ownership of their learning by driving their projects and deciding how to approach and solve problems. This sense of ownership can foster a more positive attitude toward learning, as students feel empowered and in control of their learning journey (Berliner, 2002). PjBL frequently involves collaborative teamwork on projects, fostering positive social interactions, teamwork, and communication skills. This collaborative environment contributes to a more positive learning atmosphere and attitude. The iterative nature of project-based learning encourages students to seek feedback and reflect on their progress (Hastuti et al., 2023; Isabekov & Sadyrova, 2018; Miller & Krajcik, 2019; Tamim & Grant, 2013). Through reflection, students identify areas for improvement, set goals, and develop a growth mindset, further enhancing their learning experience. This process nurtures resilience as students challenge and find innovative solutions through trial and error. Students gain a sense of ownership and pride in their work by engaging in meaningful tasks, boosting their confidence and motivation. Over time, this approach enhances academic performance and prepares students with essential skills for future academic and professional endeavors.

CONCLUSION

The results of this study highlight the significant impact of integrating project-based learning (PjBL) with Scratch programming on enhancing students' learning achievement, problem-solving skills, creativity, motivation, and attitudes. The quantitative analysis revealed that students in the plugged PjBL class demonstrated superior progress compared to their peers in both the unplugged and direct instructional (DI) classes. This suggests that hands-on, technology-enhanced activities provide deeper engagement and foster a more meaningful learning experience. The iterative and collaborative nature of Scratch-based projects encouraged students to experiment, reflect, and refine their understanding, contributing to long-term retention and skill development. These results underscore the value of incorporating digital tools like Scratch into biology

lessons to make abstract concepts more tangible and interactive. Educators can leverage this approach to create immersive learning environments that improve academic performance and cultivate essential 21st-century skills. Future studies could expand on these findings by exploring the influence of PjBL with Scratch on other subjects or demographic groups, offering broader insights into its applicability. Ultimately, this research affirms that blending project-based learning with programming tools can significantly improve students' cognitive and social development, preparing them for future academic and professional challenges.

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