JPPIPA 11(4) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Project-Based Integrated Science Learning for Developing Students' Creative Thinking Skills: A Case Study at a Madrasah Tsanawiyah in Sukabumi City

Melda Yunita[1], Elin Driana[1]*, Sri Yuliawati[1], Ernawati[1]

[1] Magister Program of Educational Research and Evaluation, Graduate School, Universitas Muhammadiyah Prof. DR. HAMKA, Jakarta, Indonesia

Received: February 19, 2025
Revised: March 23, 2025
Accepted: April 27, 2025
Published: April 30, 2025

Corresponding Author:
Elin Driana
elin.driana@uhamka.ac.id

DOI: 10.29303/jppipa.v11i4.10919

Abstract: Project-based learning (PjBL) in integrated science is an innovative approach that combines various scientific concepts through problem-based projects to enhance students' creative thinking skills by offering meaningful, contextual, and challenging learning experiences. The purpose of this study was to explore the implementation of PjBL in the integrated science subject for developing students' creative thinking skills at a Madrasah Tsanawiyah (MTs) in Sukabumi City. This study utilized a qualitative method with a case study approach. Data were gathered through observations, interviews, and document analysis. The study involved an eighth-grade integrated science teacher and 29 eighth-grade students. This study focused on project-based integrated science learning in developing students' creative thinking skills. The findings indicated that the teacher already acquired a sufficient understanding of creative thinking skills. The teacher also recognized that creative thinking skills are crucial in integrated science learning, particularly in helping students understand concepts more deeply, connect various scientific aspects, and apply concepts in real-life situations. The implementation of project-based integrated science learning at the MTs followed several stages: project planning, project execution, result presentation, and reflection. Through project-based learning, students were more motivated to think creatively, generate innovative ideas, and confidently express their opinions. Overall, project-based learning is regarded as an effective approach to fostering students' creative thinking abilities while also creating more immersive and meaningful learning experiences. These findings support the integration of project-based learning into national science education strategies and curriculum policies to enhance creative thinking skills among students across Indonesia.

Keywords: Creative Thinking Skills; Integrated Science; Madrasah Tsanawiyah; Project-Based Learning.

Introduction

Science is fundamentally essential in human life (Kemendikbudristek, 2022). As time progresses, science has become increasingly structured as a discipline that not only helps humans understand the world, but also drives various innovations and technologies that shape modern civilization (Fakaruddin et al., 2024). In education, science is one of the core subjects taught from an early age (Şener et al., 2015) because it is not merely a collection of theories about nature, but also fosters students' scientific thinking (Yager, 2009). At junior secondary level, including MTs level, science education aims not only to introduce fundamental scientific concepts, but also to develop students' creative thinking skills (Agustin et al., 2021). Through studying science, students are trained to systematically observe phenomena, ask questions, collect data, conduct experiments, and draw evidence-based conclusions (Klentien & Wannasawade, 2016). Science not only

How to Cite:
Yunita, M., Driana, E., Yuliawati , S., & Ernawati, E. (2025). Project-Based Integrated Science Learning for Developing Students' Creative Thinking Skills: A Case Study at a Madrasah Tsanawiyah in Sukabumi City. *Jurnal Penelitian Pendidikan IPA*, *11*(4), 724–735. https://doi.org/10.29303/jppipa.v11i4.10919

plays a role in providing an understanding of natural phenomena but is also closely related to the development of creative thinking skills (Daud et al., 2012).

According to Yildiz and Guler (2021), creative thinking is the ability to generate new ideas, innovative solutions, or unconventional approaches to problem-solving. Creative thinking skills are essential competencies that students must possess to face increasingly complex global challenges, where technological advancements, digitalization, and the Fourth Industrial Revolution demand individuals to think innovatively and adaptively (Fitria et al., 2024). In facing global competition, students need to develop the ability to generate original ideas, solve problems flexibly, and integrate various disciplines to create solutions relevant to contemporary needs. Creative thinking is not limited to generating new ideas, but also involves the ability to view problems from multiple perspectives, connect different concepts, and develop original and applicable solutions (Pramesti et al., 2022). Creative thinking is a fundamental component of science learning, as it not only fosters a deeper understanding of scientific concepts, but also cultivates essential problem-solving skills applicable to real-world challenges (Şener et al., 2015). Creative thinking consists of four key aspects that support problem-solving and the development of understanding: fluency, flexibility, originality, and elaboration (Yildiz & Guler, 2021). These four aspects work synergistically to help students grasp scientific concepts more effectively while also fostering thinking skills that are transferable to diverse real-world situations.

Well-designed science learning can serve as a platform for students to develop creative thinking skills (Julianto et al., 2022). However, in science education, students' creative thinking abilities often face various challenges that hinder their ability to explore new ideas and find innovative solutions to problems. One of the main issues is the lack of student motivation and interest in learning science (Chan & Norlizah, 2023). Some students perceive science as a complex and highly theoretical discipline, which often results in a reliance on rote memorization rather than a genuine comprehension and application of scientific concepts in daily life (Ariyatun, 2021). Consequently, this approach diminishes their motivation to engage in creative thinking and reinforces adherence to traditional learning patterns.

Additionally, the conventional teaching system remains a significant obstacle to foster students' creative thinking skills. Instructional methods that rely heavily on lectures and rote memorization often restrict students' opportunities to explore novel ideas. In such approaches, teachers primarily function as transmitters of information, while students passively absorb and reproduce the content presented to them (Maksic & Spasenovic, 2018). As a result, students are seldom encouraged to engage in critical thinking, pose inquiries, or participate in experimental activities that foster creativity.

Another influential factor is the lack of facilities and learning resources that support exploration-based science learning (Gustomi et al., 2025). In some cases, schools do not have adequate laboratories or sufficient teaching aids to support scientific experiments and projects (Klentien & Wannasawade, 2016). As a result, students understand concepts theoretically but lack opportunities to test and deepen their understanding through hands-on experiences. Moreover, the low level of student collaboration skills in science learning further hinders the development of creative thinking, problem-solving, and effective communication. To address this, more interactive and cooperative learning strategies are needed to enhance students' collaborative skills (Afelia et al., 2023). This way, students can actively exchange ideas, solve problems together, and develop creative thinking and communication skills effectively in science learning. One approach that can be implemented to overcome these challenges is project-based learning (Daud et al., 2012).

PjBL is a teaching method that places students at the center of the learning process by providing authentic projects that challenge them to solve problems or create a product (Nurhidayah & Wibowo, 2019). According to Musa et al. (2011), PjBL is a learning model that engages students in complex projects based on real-world problems. This approach offers a more contextual and interactive learning experience, requiring students to utilize various skills, including critical and creative thinking (Krajcik et al., 2023). In the context of creative thinking, PjBL is highly effective as it encourages students to explore multiple alternative solutions to a problem, take risks in trying different approaches, and produce original outcomes (Nurhidayah & Wibowo, 2019). This model emphasizes independent learning, collaboration, and multi-perspective exploration, which are directly linked to the development of creative thinking skills (Saenab et al., 2019). Through self-exploration, collaborative work, and deep reflection, this approach aligns with 21st-century education demands, which emphasize creativity, innovation, and complex problem-solving (Samsudin et al., 2023).

PjBL provides students with opportunities to develop creative thinking skills by encouraging them to design, evaluate, and implement innovative solutions to real-world problems (Cort et al., 2021). PjBL is one of the instructional approaches that can help students enhance 21st-century skills (Dewi & Arifin, 2024; Rati et al., 2023).

Additionally, PjBL has been shown to improve students' critical and creative thinking skills (Ariyatun, 2021; Julianto et al., 2022). This strategy also encourages students to think exploratively, take risks, experiment, and demonstrate resilience in their creative endeavors (Albar & Southcott, 2021). PjBL can serve as an effective means of increasing student engagement (Juuti et al., 2021; Rahma et al., 2023). It enhances active student participation by encouraging them to share knowledge, exchange information, and engage in discussions (Almulla, 2020). Furthermore, PjBL has been proven effective in fostering student collaboration (Hairida et al., 2021; Huysken et al., 2019; Markula & Aksela, 2023). Through this method, students learn to work together, share their creative ideas, and complete tasks collaboratively (Janah, 2022). The implementation of PjBL in science education has also been shown to have a significant impact on student learning outcomes (Kartika, 2023; Rati et al., 2023; Suprapti, 2021).

Previous research has explored the effectiveness of PjBL in enhancing creative thinking skills across different educational levels and disciplines. Various studies indicate that PJBL provides a conducive learning environment for fostering creative thinking skills. This approach enables students to think more flexibly, generate innovative solutions, and connect learned concepts with real-life situations (Achmad et al., 2024). By allowing students the freedom to explore ideas, they are more motivated to discover new and more effective approaches in addressing the challenges posed in their projects. Additionally, this method helps students link the concepts they learn to everyday life, making learning more meaningful (Krajcik et al., 2023). When students see the relevance of classroom theories to real-world situations, they become more motivated to think creatively in applying their knowledge. PjBL also fosters students' confidence in presenting their ideas and taking risks in developing solutions that have not been previously attempted (Nurhidayah & Wibowo, 2019). In other words, this method not only sharpens individual creative thinking skills, but also cultivates an innovative mindset that is crucial for addressing modern challenges (Dewi & Arifin, 2024). In the context of Integrated Science education at MTS, teachers' understanding of creative thinking skills and the implementation of project-based learning remains a subject that warrants further investigation. Although previous studies have examined the effectiveness of this learning model across various levels of education, most have been conducted in schools with adequate facilities and relatively complete supporting resources. This leaves a research gap, particularly in the context of madrasahs or schools with limited resources—such as the lack of laboratories, insufficient teaching aids, and minimal teacher training in innovative learning methods. Madrasahs possess unique characteristics in terms of both their students and learning environments, which require contextual and adaptive approaches to implementing PjBL. Therefore, this study was designed to explore in depth teachers' understanding of creative thinking skills in integrated science instruction, as well as to analyze the extent to which teachers master the concept of PjBL and how it was implemented amid limitations in facilities and infrastructure. The findings of this research are expected to contribute significantly to the development of a contextual and practical model of integrated science learning tailored to the specific needs and constraints of madrasahs with limited resources.

Method

The study was conducted at one of the MTs (Islamic Junior High Schools) in Sukabumi City, from July 2022 to August 2022. This research was carried out qualitatively using a case study approach (Hatch, 2002). The case study approach was chosen to explore in-depth the implementation of project-based learning in integrated science education and its impact on students' creative thinking skills in MTs. It covers teachers' understanding of creative thinking skills, project-based science learning, and its implementation in the classroom. This approach was selected because each school has different conditions, so the way project-based learning is integrated into creative thinking skills in science education can vary significantly.

This study was conducted with an eighth-grade integrated science teacher and a class of 29 students. The eighth grade was chosen because students at this level have already acquired foundational scientific knowledge from previous coursework, equipping them with the necessary background to engage effectively in project-based learning that emphasizes exploration, problem-solving, and innovation. To ensure the confidentiality of informants and protect their personal data, coded identifiers were used to maintain anonymity, fostering a secure environment in which informants could share their experiences and perspectives openly and honestly. Additionally, the name of the MTS was withheld to preserve institutional privacy.

Data were obtained through observations, interviews, and an analysis of documents. The observation method used in this study was non-interactive participatory observation (Stickdorn et al., 2018), where the researcher (the first author) was present in the classroom but did not interfere with the learning process. Observations were carried out during science lessons based on a schedule agreed upon with the teacher. The researcher used a structured observation sheet prepared in advance to record key aspects of the implementation. Each observation session lasted according to the standard learning duration in the MTs, ranging from 45 to 90 minutes. Observations were conducted in three sessions to ensure that the data obtained were more comprehensive and accurate.

The interviews conducted in this study were semi-structured interviews (Creswell & Poth, 2017). The researcher used an interview guide consisting of a set of pre-prepared questions while allowing informants to elaborate on their responses in-depth or add any relevant information. Interviews were conducted in person to enable the researcher to observe the informants' body language and facial expressions and to ask follow-up questions to clarify or further explore responses if necessary. Interviews were conducted in the teachers' lounge, with a duration of approximately 15 to 35 minutes per session. With the informants' permission, the researcher used a voice recorder to document the conversations and also took notes on key points during the interview sessions. Based on the explanation above, the following table provides a brief overview of the results of the observations and interviews conducted.

Table 1. Summary of Observation and Interview Stages

Method	Implementation Stages	Number of Sessions/Duration
Observation	- Non-interactive (researcher present, no intervention) - Based on teacher's schedule - Using a structured observation sheet - Conducted during integrated science lessons	3 sessions (each lasting 45–90 minutes)
Interview	- Semi-structured - Direct interview with 8th-grade integrated science teacher - Open-ended question guide - Conducted in the teachers' room - Recorded and noted with participant's consent	2 sessions (15–35 minutes per session)

In addition to observations and interviews, document analysis was conducted to collect relevant materials related to project-based science learning aimed at fostering students' creative thinking skills. These documents included syllabi and lesson plans, textbooks and teaching modules, student worksheets (LKS), student assessment results, and project documentation. These documents were collected to gain an overview of how project-based learning was integrated into science education.

Data analysis in this study followed the model developed by Miles, Huberman, and Saldana (2014), which consists of three main stages: data condensation, data display, and conclusion drawing. In the data condensation stage, the researcher filtered and organized data to identify key themes, emerging patterns, or relevant categories (Kalpokaite & Radivojevic, 2019). Next, data display was conducted in the form of tables to facilitate pattern recognition and relationships within the data, allowing for a more systematic analysis (Linneberg & Korsgaard, 2019). The final stage, conclusion drawing, was carried out by examining identified patterns and ensuring their validity through triangulation, making the research findings more accurate and reliable (Creswell & Poth, 2017). This study employed a diversity of sources and techniques (Fusch et al., 2018). The diversity of sources included primary sources, namely eighth-grade integrated science teachers, and secondary sources, which consisted of syllabi and lesson plans, textbooks and teaching modules, student worksheets (LKS), student assessment results, and project documentation. The diversity of techniques in this research included observation, interviews, and document analysis.

Result and Discussion

The research on the implementation of project-based integrated science learning in enhancing students' creative thinking skills at an MTs in Sukabumi city yielded several key findings. These findings were categorized based on the research focus, namely teachers' understanding of the concept of creative thinking skills in integrated science learning, including the extent to which they recognize the importance of these skills in improving students' abilities. Furthermore, the study revealed how teachers comprehend PjBL in integrated science, particularly in its application to enhance student engagement and understanding of the subject matter. Lastly, the study described the implementation of project-based integrated science learning in the classroom.

Teacher's Understanding of Creative Thinking Skills in Integrated Science

Creative thinking skills are essential competencies in integrated science learning. Teachers play a key role in developing these skills through various teaching approaches that encourage students to think originally, flexibly, and innovatively when solving given problems (Chintya et al., 2023). The findings on teacher' understanding of creative thinking skills in integrated science cover several key aspects, including the definition of creative thinking skills, its indicators, and teaching strategies that support creative thinking. The findings indicated that teachers understood that creative thinking skills refer to students' ability to generate new ideas, explore various possible solutions, and connect scientific concepts in different contexts. This understanding is reflected in the following interview excerpt:

> *"In my opinion, creative thinking skills in science encompass students' ability to generate innovative ideas, explore different solutions, and establish new connections between scientific concepts. These skills not only help students comprehend theories, but also allow them to apply their knowledge in real-world contexts through investigation, experimentation, and problem-solving." (G.IPA-8)*

The above definition aligned with Krajcik et al., (2023), who stated that creative thinking in science learning is students' ability to design new ideas, discover innovative solutions, and apply scientific concepts to understand phenomena and solve problems effectively. Creative thinking skills are crucial for helping students address challenges and develop new concepts (Chintya et al., 2023). Students with creative thinking skills tend to find alternative solutions more easily, adapt to changes, and innovate in idea development (Şener et al., 2015). Creative thinking skills have several key indicators that can be used to assess a person's ability to generate new and innovative ideas. This is reflected in the following interview excerpt:

> *"In my opinion, the indicators of creative thinking encompass fluency, which refers to the ability to generate multiple ideas; flexibility, which involves considering problems from various viewpoints; originality, which reflects the willingness to experiment with new approaches; and elaboration, which denotes the capacity to develop and enhance ideas further." (G.IPA-8)*

Yildiz and Guler (2021) described creative thinking as having four dimensions: fluency (generating ideas), originality (producing unique ideas), elaboration (adding details to refine products), and flexibility (producing different categories of ideas). Creative thinking skills in science are vital for fostering a deeper scientific understanding and promoting innovation in problem-solving. By developing fluency, flexibility, originality, elaboration, and sensitivity to problems, students can become individuals capable of tackling global challenges with a creative scientific approach (Albar & Southcott, 2021). Therefore, teachers must adopt instructional strategies that support the development of these skills, such as encouraging idea exploration, providing challenges that stimulate creativity, and creating a collaborative and innovative learning environment. This is supported by the following interview excerpt:

> *"I implement creative thinking strategies by presenting real-world problems, encouraging experiments through inquiry, open discussions, and project-based assignments so that students can generate innovative ideas." (G.IPA-8)*

To develop creative thinking skills in science learning, teaching strategies should not only focus on conceptual understanding, but also encourage students to explore ideas, find innovative solutions, and integrate various disciplines flexibly (Daud et al., 2012). This approach ensures that students not only understand scientific concepts in depth, but also apply them in different contexts to solve problems creatively and effectively. Developing creative thinking skills in science will enhance students' understanding of scientific concepts and prepare them to be innovative individuals ready to face future challenges (Yildiz & Guler, 2021).

Teacher Understanding of Project-Based Learning in Integrated Science

PjBL has become one of the most widely implemented approaches in education, including in integrated science instruction (Markula & Aksela, 2023). Teachers' understanding of PjBL significantly determines its success in the classroom. Teachers who comprehend this concept not only see PjBL as a strategy to enhance students' conceptual understanding, but also as a means to foster critical thinking, creativity, and collaboration skills (Hairida et al., 2021). Based on the findings, teacher' understanding of project-based learning in integrated science can be categorized into several key aspects. First, understanding the fundamental concept of PjBL. Second, understanding the teacher's role in PjBL. Third, understanding how to integrate PjBL into integrated science learning.

PjBL has become an innovative strategy that allows students to learn more actively and contextually. This method emphasizes not only knowledge transfer, but also the development of 21st-century skills such as critical thinking, problem-solving, collaboration, and communication (Dewi & Arifin, 2024). Therefore, teachers' understanding of the PjBL concept is a fundamental aspect of the successful implementation of this method, especially in science education, which is based on experimentation and scientific exploration. Regarding the PjBL concept, the teacher at MTs Sukabumi City had understood that this approach is a learning strategy that emphasizes active student involvement in completing a project based on real-world problems. As explained in the following interview excerpt:

> "*Integrated Science learning based on projects is an approach that connects science concepts through real-world projects. Students not only learn theories, but also apply them in everyday life, such as conducting experiments or creating products. This model encourages critical thinking, collaboration, and problem-solving skills.*" (G.IPA-8)

Through PjBL, students are encouraged to think critically, work collaboratively in groups, and develop creative thinking skills. As Almulla (2020) explained, PjBL is a learning approach that emphasizes students' active involvement in exploring, researching, and completing projects based on real-world problems. In PjBL, students do not passively receive information from teachers; instead, they play an active role in finding solutions, collecting data, analyzing, and presenting their project results (Hairida et al., 2021). The teacher in this study recognized that PjBL is not merely about assigning students a project but rather a systematic approach that guides students to investigate, explore, and find solutions to problems relevant to everyday life. This understanding motivates them to design projects that allow students to conduct scientific investigations, perform simple experiments, and develop evidence-based problem-solving skills.

The role of teachers in PjBL is no longer limited to delivering material but extends to being facilitators and mentors who help students design projects, explore concepts, and find solutions to given problems. As stated in the following interview excerpt:

> "*In project-based learning, the teacher acts as a facilitator, motivator, and evaluator. Additionally, the teacher guides, encourages creativity, and assesses both the process and the learning outcomes of students.*" (G.IPA-8)

This explanation was reinforced by observations showing that teacher was not only delivering instructional material, but also serving as facilitators, mentors, and motivators who helped students learn through direct experience. In PjBL, teachers play a crucial role as facilitators who guide students in exploring and completing their projects. In line with this, Chintya et al. (2023) stated that in PjBL, teachers do not merely teach, but also act as facilitators, mentors, and motivators who support students in learning independently and meaningfully. Throughout the learning process, teachers are always present to provide direction and guidance. They assist students in understanding the problems they need to solve, designing research strategies, and utilizing various learning resources to support their projects. Through this approach, students are trained to think independently and solve problems systematically. This method enables students to learn through direct experience by working on projects relevant to their lives.

Therefore, teacher's understanding of how to integrate PjBL into integrated science learning is essential for creating a more meaningful learning experience for students. The teacher in this study had understood how to integrate PjBL into integrated science education as an effort to enhance students' conceptual understanding and creative thinking skills. This is conveyed in the following interview excerpt:

> "*I integrate project-based learning into science learning by designing problem-based projects, guiding students' exploration through experiments and discussions. With this approach, students not only understand concepts, but also develop critical and creative thinking skills in problem-solving.*" (G.IPA-8)

In integrated science learning, PjBL can be integrated as an engaging and meaningful approach because it connects various scientific concepts into a comprehensive and applicable unit (Rahma et al., 2023). Klentien and Wannasawade (2016) stated that in the context of science learning, projects designed in PjBL can include investigations of natural phenomena, laboratory experiments, or the development of solutions to environmental problems. This approach fosters independence, collaboration, and experimentation in students (Kartika, 2023). Through this approach, science learning in the MTs becomes more meaningful, interactive, and problem-solving-oriented. Students do not merely understand science theories passively, but also become critical thinkers capable of connecting scientific knowledge with everyday life.

Implementation of Integrated Science Learning Based on Project-Based Learning in Students' Creative Thinking Skills

Project-based integrated science learning is an approach that positions students as the main actors in learning, where they actively explore, investigate, and create solutions to real-world problems (Almulla, 2020). This learning model not only enhances students' comprehensive understanding of science concepts, but also develops creative thinking skills, which are essential in the 21st century (Albar & Southcott, 2021). In the implementation of PjBL in integrated science subject, several key aspects must be considered to optimally develop students' creative thinking skills. Based the findings, these aspects include planning, implementation, and challenges encountered during execution. Project-based integrated science learning is designed to provide students with more meaningful learning experiences (Pramesti et al., 2022). Therefore, the planning stage in the implementation of this learning approach is crucial to ensuring that the intended objectives are achieved optimally.

Based on the findings, the first stage in planning was determining the learning objectives. These objectives included students' ability to generate new ideas, formulate innovative solutions, and connect theoretical concepts with real-world applications. Once the learning objectives are established, the next step was selecting a relevant project topic or theme that aligns with the lesson content. The teacher then developed a systematic project plan, outlining the steps to be taken throughout the project, from the exploration and experimentation phases to the preparation of reports and presentation of project outcomes. Additionally, the teacher needed to determine the student work model—whether the project will be conducted individually or in groups. To ensure objective assessment, the teacher must prepare appropriate assessment instruments. In this context, a scoring rubric serves as an effective tool for evaluating students' creative thinking skills. Assessment is conducted based on various aspects, such as originality of ideas, students' ability to develop solutions, and how well they connect science concepts with real-world applications.

Wida et al. (2024) stated that in the implementation PjBL in integrated science, the development of students' creative thinking skills depends on planning, execution, assessment, as well as supporting factors and challenges encountered during implementation. This statement aligned with Puspita et al. (2022) who asserted that the successful implementation of PjBL requires systematic planning, effective execution, and appropriate assessment to foster students' creative thinking skills. With well-structured planning, project-based integrated science learning can be an effective strategy to enhance students' creative thinking.

The implementation of project-based integrated science learning is designed to provide an active and contextual learning experience that encourages students' creativity. Through this process, students not only understand scientific concepts theoretically, but also apply them in real-world projects that challenge their creative thinking skills (Pramesti et al., 2022). Based on observations, the implementation began with project introduction, where the teacher explained the learning objectives, topics to be explored, and the problems or challenges that students needed to solve. At this stage, the teacher employed stimulus strategies such as open-ended questions and simple demonstrations to spark students' curiosity. Next, students were divided into groups and begin designing projects based on the given problem. In this study, the teacher assigned each student group a project to create a slingshot, with the main topic being motion in objects. In the slingshot-making project, creative thinking played a crucial role in every stage of design and development. Fluency was demonstrated when students generate multiple ideas regarding the slingshot's design and materials. Flexibility was evident as students try various approaches in building the slingshot, such as exploring different handle shapes for better grip comfort and testing various elastic bands to determine which provided the best propulsion force. Originality emerged when students introduced unique innovations, such as adding a spring mechanism or designing an ergonomic handle to improve slingshot performance. Elaboration was seen in the refinement phase, where students not only constructed the slingshot, but also focused on details like smoothing the wooden handle for comfort, securing the elastic bands tightly to prevent detachment, and testing different launching angles to optimize the slingshot's performance. In this activity, the teacher acted as a facilitator, guiding, providing feedback, and encouraging students to think more deeply about their results. The next stage involved writing reports and presenting the project. This presentation phase not only enhanced students' critical and creative thinking skills, but also improved their communication and collaboration abilities. As a final step, the teacher assessed the project by evaluating aspects such as innovation, problem-solving, and students' understanding of scientific concepts. Feedbacks were provided to enhance the quality of learning in future projects.

In the global context, the approach to science education continues to undergo transformation to meet the demands of the 21st century. One of the international standards that emphasizes the importance of developing creative thinking skills and collaborative problem-solving is the Next Generation Science Standards (NGSS). NGSS highlights the integration of scientific practices, cross-disciplinary concepts, and mastery of core ideas as the foundation for meaningful, contextual, and real-life-oriented science learning (States, 2013). This approach is closely related to the PjBL model implemented in this study. PjBL provides students with the opportunity to be directly involved in real-world problem-based projects, develop questions, design solutions, conduct scientific exploration, and critically reflect on outcomes. Through project implementation, students not only deepen their understanding of scientific concepts, but also sharpen their creative thinking skills, which include fluency, flexibility, originality, and elaboration—the four key pillars of creative thinking. To clarify, the following is a brief table illustrating the relationship between creative thinking aspects and the science and engineering practices in NGSS:

Table 2. Comparison of Field Findings and NGSS

Creative Thinking Aspect	Example in the Slingshot Project	Relevance to NGSS (Science and Engineering Practices)
Fluency (Generating Many Ideas)	Generating many design ideas and alternative materials for the slingshot.	Asking questions; Defining problems; Generating multiple solutions.
Flexibility (Shifting Perspectives or Approaches)	Adjusting the design and materials based on challenges and experiments.	Planning investigations; Exploring multiple strategies for design solutions.
Originality (Producing Novel Ideas)	Adding innovations such as springs or unique ergonomic shapes.	Designing innovative solutions; Developing creative approaches to constraints.
Elaboration (Adding Detail and Complexity)	Refining the design, testing launch angles, considering aesthetics and functionality.	Analyzing and interpreting data; Refining models and designs based on feedback.

The table above illustrates the close relationship between the implementation of PjBL in this study and the principles of the Next Generation Science Standards (NGSS) in the development of creative thinking skills. The four aspects of creative thinking—fluency, flexibility, originality, and elaboration—are not only reflected in students' behavior during the project, but also align with the scientific practices recommended by NGSS. Specifically, students demonstrate fluency through their ability to propose various catapult design alternatives, which directly relates to the practice of "Asking Questions and Defining Problems" in NGSS. Their flexibility in exploring different materials and technical approaches indicates involvement in "Developing and Using Models." The originality displayed in the students' catapult design innovations shows that they have internalized the practice of "Designing Solutions," while the efforts in refinement and reflection within the project indicate the practice of "Constructing Explanations" as outlined in NGSS.

These findings reinforce that the PjBL approach is effective in facilitating the development of creative thinking skills, integrated with the learning of scientific concepts. Even in the context of limited facilities in the madrasah, the skills developed through PjBL are still in line with the direction of science education reform based on NGSS, which emphasizes the development of higher order thinking, creativity, and the application of concepts in real world contexts. Therefore, the implementation of PjBL in science education is not only relevant for improving cognitive learning outcomes, but also strategic in building the foundation for 21st-century skills that students will need to face the complexities of global challenges in the future (Yildiz & Guler, 2021).

During the implementation of PjBL in slingshot construction, students' attitudes and perceptions exhibited diverse responses. Most students found this activity engaging and enjoyable because they could learn directly through hands-on practice. They felt it was easier to understand concepts of motion in objects, such as force, elasticity, and acceleration, when applying them in a real project. However, not all students felt comfortable with this learning method. Some expressed difficulties in collaboration, particularly in dividing tasks and integrating ideas within their groups. Others lacked confidence in decision-making, leading them to rely more on instructions from peers or teachers. Overall, PjBL received positive responses from students. This project not only helped them better understand science concepts, but also trained their teamwork skills, creativity, and perseverance in problem-solving. Previous studies have also proven that PjBL can enhance students' critical and analytical thinking skills, encourage exploration, strengthen cooperation, and develop communication skills (Janah, 2022). Furthermore, this model fosters student engagement in the learning process and leads to better comprehension of the material (Zaharah & Silitonga, 2023). This finding aligned with a study conducted by Suprapti (2021), who stated that after implementing PjBL, there was an improvement in students' learning outcomes, including cognitive, affective, and psychomotor aspects.

In the implementation of integrated science project-based learning, several obstacles emerged that could affect its effectiveness. Regarding these challenges, the following is an excerpt from an interview conducted with G.IPA-8, a teacher who has implemented this method in class:

> "*The challenges I faced in implementing project-based science learning include limited laboratory equipment and materials. The time allocated in the lesson schedule is often insufficient to complete the project properly. Additionally, differences in students' abilities also pose a challenge, as some are active and quick to understand, while others require more guidance.*"

The statement above was further supported by observational findings, which indicated that one of the primary challenges in implementation was the limited resources, both in terms of facilities and teaching materials. Without adequate resources, teachers and students must find alternatives to ensure the project is still carried out despite the limitations. This aligned with Klentien dan Wannasawade (2016) who stated that in project-based learning, resource limitations present a significant challenge, such as the lack of sufficient laboratory equipment and materials. To address this issue, teachers can provide alternative materials that are simpler and more readily available in the surrounding environment to ensure students still have an optimal learning experience.

Another factor that poses a challenge was students' levels of motivation and independence. In PjBL, students are required to be active, independent, and capable of working collaboratively in teams. However, not all students possess these characteristics. Some students lacked confidence in expressing ideas, remained passive in group discussions, or were not accustomed to thinking creatively when solving problems. Observations showed that while some students were enthusiastic and actively sought solutions to the given challenges—such as experimenting with alternative materials for catapult construction and discussing the most effective design with their team—others were less motivated and tended to be passive in group work. Some students simply waited for instructions from their peers or the teacher without actively contributing to the design and construction process. Some also struggled with decision-making or completing tasks independently, causing their projects to progress more slowly than others. Additionally, certain groups encountered difficulties in collaboration, such as challenges in dividing tasks fairly or differing opinions that led to a lack of coordination within the team. These findings were consistent with Zaharah and Silitonga (2023), who stated that in the PjBL process, students with better understanding tend to be more active and complete tasks quickly, whereas students with lower abilities often struggle, procrastinate, engage in off-topic conversations, or even disrupt those who are focused on learning. Therefore, teachers must effectively manage these issues by implementing additional strategies to boost students' motivation and independence. These strategies include assigning clear roles within teams, providing more targeted guidance for less active students, and offering incentives for those who demonstrate initiative and effective teamwork.

Time constraints in learning also posed a challenge in PjBL implementation. Since this method requires a lengthy process, from planning and execution to evaluation, the available lesson time is often insufficient for completing the project optimally. Consequently, teachers must manage time effectively to ensure the project progresses without disrupting the completion of the curriculum. These confirmed the findings of Febiyanti et al. (2024) who emphasized that effective time management is crucial in implementing PjBL, as this method requires a longer duration than conventional learning. Therefore, teachers need to design strategies that ensure all curriculum materials are delivered effectively.

Despite these challenges, project-based integrated science learning remains highly effective in fostering students' creative thinking skills. By cultivating their ability to think innovatively, work autonomously, and engage in problem-solving, this approach equips students with essential competencies that are crucial for both professional environments and everyday life (Şener et al., 2015). Additionally, the experience of working in teams, managing projects, and overcoming challenges helps students become more adaptable individuals, better prepared to face an increasingly complex world (Nurhidayah & Wibowo, 2019). Thus, PjBL not only improves academic understanding, but also shapes essential 21st-century skills that are crucial for students' futures (Samsudin et al., 2023). With support in teacher training, better learning resources, and strategies that foster student motivation and participation, these challenges can be overcome to ensure more effective implementation of PjBL in schools.

Conclusion

This study demonstrated that the integrated science teacher has possessed a sufficient understanding of creative thinking skills and acknowledges their critical role in science education. Specifically, the teacher recognized that fostering creative thinking is essential for enabling students to develop a deeper understanding of scientific concepts, establish connections between different scientific disciplines, and apply their knowledge to real-world contexts. The implementation PjBL was found to enhance student motivation, encouraging them to think creatively, generate innovative ideas, and confidently articulate their perspectives.

However, the integration of PjBL in science education encountered several challenges, including limited facilities and teaching resources, variations in student motivation and engagement levels, and time constraints. Despite these obstacles, PjBL remains an effective approach for cultivating students' creative thinking skills while promoting a more engaging and meaningful learning experience. Addressing these challenges through targeted teacher training, improved access to learning resources, and strategies that enhance student motivation and participation would further support the successful implementation of PjBL in schools.

The results of this study can serve as a foundation for the development of PjBL worksheets for science subjects at the junior high school level and for teacher training in implementing PjBL. This development is expected to improve the quality of education by providing more contextual learning experiences, encouraging active student engagement, and enhancing creative thinking and problem-solving skills. Additionally, teacher training focused on PjBL management strategies can facilitate the more effective implementation of this method, enriching teachers' pedagogical abilities in integrating scientific concepts with real-world scientific practices, as well as boosting students' motivation to learn independently and collaboratively.

Acknowledgments
We extend our gratitude to the Directorate of Research, Technology, and Community Service, Directorate General of Research and Development Enhancement, Ministry of Education, Culture, Research, and Technology, for funding this research. We also express our appreciation to the Research and Development Institute of Universitas Muhammadiyah Prof. DR. UHAMKA for their support. We extend our deepest gratitude to the principal of the MTs for the opportunity to conduct this research as well as the teacher and the students at MTS for their participation in this research and for providing valuable insights and experiences regarding the implementation of project-based learning in integrated science.

Author Contributions
Conceptualization and research design: MY, ED, and SY; instrument development: MY, ED, and SY; data collection, MY.; data analysis: MY and E; writing—original draft preparation, MY and E; writing—review, ED and SY. writing—editing, ED and E. All authors have read and agreed to the published version of the manuscript.

Funding
This research was supported by a grant from the Directorate of Research, Technology, and Community Service, Directorate General of Research and Development Enhancement, Ministry of Education, Culture, Research, and Technology with a contract number 429/LL3/AK.04/2022, 461/F.03.07/2022, which provided financial assistance for the research implementation.

Conflicts of Interest
The authors declared there are no conflicts of interest in this research.

References

Achmad, A. A., Zulfiani, Z., & Solihin, S. (2024). Development of live worksheet based on project-based learning to promote creative thinking and ecopreneurship on biotechnology Concepts. *International Journal of STEM Education for Sustainibility*, *4*(2), 176–201. https://doi.org/10.52889/ijses.v4i2.409

Afelia, Y.D., Utomo, A. P., & Sulistyaningsih, H. (2023). Implementasi model problem based learning (PJBL) berbasis pembelajaran berdiferensiasi untuk meningkatkan keterampilan kolaborasi pada mata pelajaran biologi di kelas X SMA [Implementation of the problem-based learning (PJBL) model with differentiated instruction to enhance collaboration skills in biology for 10th grade high school students]. *Jurnal Biologi*, *1*(2), 1–11. https://doi.org/10.47134/biology.v1i2.1963

Agustin, S. B., Asrizal, A., & Festiyed, F. (2021). Analisis effect size pengaruh bahan ajar IPA bermuatan literasi sains terhadap hasil belajar siswa SMP/MTS [Effect size analysis of the influence of science-literacy-integrated teaching materials on SMP/MTS]. *Jurnal IPA & Pembelajaran IPA*, *5*(2), 125–137. https://doi.org/10.24815/jipi.v5i2.19606

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*(June), 100853. https://doi.org/10.1016/j.tsc.2021.100853

Almulla, M. A. (2020). The effectiveness of the project-based learning (PJBL) approach as a way to engage students in learning. *Sage Journal*. https://doi.org/10.1177/2158244020938702

Ariyatun. (2021). Analysis of project based learning integrated with ethno-stem on students ' critical and creative thinking skills. *Jornal Of Education Chemistry*, *3*(1), 35–44. https://doi.org/10.21580/jec.2021.3.1.6574

Chan, Y.L., & Norlizah, C.H. (2023). Students ' motivation towards science learning and students' science achievement. January *2018*. https://doi.org/10.6007/IJARPED/v6-i4/3716

Chintya, J., Haryani, S., Linuwih, S., & Marwoto, P. (2023). Analysis of the application of the project based learning (PjBL) learning model on increasing student creativity in science learning in elementary schools. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4558–4565. https://doi.org/10.29303/jppipa.v9i6.2726

Cort, C., Nussbaum, M., Harcha, J., Alvares, D., & Felipe, L. (2021). Computers in human behavior promoting critical thinking in an online , project-based course. *Computers in Human Behavior Journal*, *119*(October 2020). https://doi.org/10.1016/j.chb.2021.106705

Creswell, J. W., & Poth, C. N. (2017). Qualitative inquiry & research designe (Fourth Edi). SAGE Publications.

Daud, A. M., Omar, J., Turiman, P., & Osman, K. (2012). Creativity in science education. *Procedia - Social and Behavioral Sciences*, *59*, 467–474. https://doi.org/10.1016/j.sbspro.2012.09.302

Dewi, M. R. & Arifin, Z. (2024). Analysis of 21 st century skills in the implementation of project based learning in biology learning merdeka curriculum. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 2118–2127. https://doi.org/10.29303/jppipa.v10i4.5941

Fakaruddin, F.J., Shahali, E. H. M., & Saat, R. M. (2024). Creative thinking patterns in primary school students' hands-on science activities involving robotic as learning tools. *Asia Pacific Education Review*, *25*(1), 171–186. https://doi.org/10.1007/s12564-023-09825-5

Febiyanti, S., Adri, H. T., & Indra, S. (2024). Analisis implementasi model pembelajaran project based learning pada keaktifan belajar IPA siswa kelas IV sekolah dasar SDN Babakan Madang 05 [Analysis of the implementation of the project-based learning model on the science learning activeness of fourth-grade students at SDN Babakan Madang 05]. *Karimah Tauhid*, *3*, 9116–9125. https://doi.org/10.30997/karimahtauhid.v3i8.14986

Fitria, D., Dhanil, M., & Lufri, L (2024). Impact of blended problem-based learning on students ' 21st century skills on science learning : a meta- analysis. *International Journal of Education in Mathematics, Science and Technology*, *12*(4), 1032–1052. https://doi.org /10.46328/ijemst.4080

Fusch, P., Fusch, G. E., & Ness, L. R. (2018). Denzin's paradigm shift: revisiting triangulation in qualitative research. *Journal of Social Change*, *10*(1), 19–32. https://doi.org/10.5590/josc.2018.10.1.02

Gustomi, Driana, E., & Ernawati. (2025). The utilization of virtual laboratories in science education at junior secondary schools in Tangerang Regency. *Jurnal Penelitian Pendidikan IPA*, *11*(1), 876–886. https://doi.org/10.29303/jppipa.v11i1.9075

Hairida, Marmawi, M., & Kartono, K. (2021). An analysis of students' collaboration skills in science learning through inquiry and project-based learning. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *6*(2), 219–228. https://doi.org/10.24042/tadris.v6i2.9320

Hatch, J. A. (2002). *Doing qualitative research in education settings*. State University of New York Press, Albany.

Huysken, K., Olivey, H., & Mcelmurry, K. (2019). Assessing collaborative , project-based learning models in introductory science courses. *Journal of the Scholarship of Teaching and Learning*, *19*(1), 6–28. https://doi.org/10.14434/josotl.v19i1.26777

Janah, M. (2022). Efektifitas model pembelajaran problem based learning (PJBL) berbasis e-worksheet untuk meningkatkan hasil belajar dan keaktifan siswa [The effectiveness of problem-based learning (PJBL) model based on e-worksheet to improve students' learning outcomes and activeness]. *Prosiding National Simposium & Conference Ahlimedia*, *1*(1), 160–167. https://doi.org/10.47387/nasca.v1i1.28

Julianto, Wasis, W., Agustini, R., Suprayitno, S., Rukmi, A. S., Hidayati, F., & Rahmawati, E. (2022). Creative attitude in science learning model to improve creative thinking skills and positive attitude of students towards science. *IJORER : International Journal of Recent Educational Research*, *3*(6), 701–717. https://doi.org/10.46245/ijorer.v3i6.255

Juuti, K., Lavonen, J., Salonen, V., Salmela-aro, K., Krajcik, (2021). A teacher – researcher partnership for professional learning : co-designing project-based learning units to increase student engagement in science classes . *Journal of Science Teacher Education*, *32*(6), 625–641. https://doi.org/10.1080/1046560X.2021.1872207

Kalpokaite, N., & Radivojevic, I. (2019). Demystifying qualitative data analysis for novice qualitative researchers. *Qualitative Report*, *24*(13), 44–57. https://doi.org/10.46743/2160-3715/2019.4120

Kartika, R. W. . (2023). Meningkatkan hasil belajar IPA siswa SMP melalui penerapan model pembelajaran berbasis proyek pada materi bioteknologi [Improving junior high school students' science learning outcomes through the implementation of project-based learning model on biotechnology material] *Jurnal FUSION*, *3*(04). https://doi.org/10.54543/fusion.v3i04.293

Kemendikbudristek. (2022). Capaian pembelajaran mata pelajaran ilmu pengetahuan alam (IPA) Fase D. *Badan Standar Kurukulum dan Asesmen Pendidikan Republik Indonesia*.

Klentien, U. & Wannasawade, W. (2016). Development of blended learning model with virtual science laboratory for secondary students. *Procedia - Social and Behavioral Sciences*, *217*(2), 706–711. https://doi.org/10.1016/j.sbspro.2016.02.126

Krajcik, J., Schneider, B., Miller, E. A., Chen, I. C., Bradford, L., Baker, Q., Bartz, K., Miller, C., Li, T., Codere, S., & Peek-Brown, D. (2023). Assessing the effect of project-based learning on science learning in elementary schools. *American Educational Research Journal*, *60*(1), 70–102. https://doi.org/10.3102/00028312221129247

Linneberg, M.S., & Korsgaard, S. (2019). Coding qualitative data: a synthesis guiding the novice. *Qualitative Research Journal*, *19*(3), 259–270. https://doi.org/ 10.1108/QRJ-12-2018-0012

Maksic, S. B. & Spasenovic, V. Z. (2018). Educational science students ' implicit theories of creativity. *Creativity Research Journal*, *30*(3), 287–294. https://doi.org/10.1080/10400419.2018.1488200

Markula, A. & Aksela, M. (2023). Enhancing the 4Cs among college students of a communication skills course in Tanzania through a project-based learning model. *Disciplinary and Interdisciplinary Science Education Research*, *28*(6), 6269–6285. Https://doi.org/10.1007/s10639-022-11406-9

Miles, M. B., & Huberman, A. M., & Saldana, J.(2014). Qualitative data analysis, A Methods Sourcebook.

Musa, F., Mufti, N., Latiff, R. A., & Amin, M. M. (2011). Project-based learning : promoting meaningful language learning for workplace skills. *Procedia Social and Behavioral Sciences*, *18*, 187–195. https://doi.org/10.1016/j.sbspro.2011.05.027

Nurhidayah, I.J., Wibowo, F.C., & Astra, I.M. (2019). Project based learning (PjBL) learning model in science learning : literature review. *Journal of Physics: Conference Series*. https://doi.org/10.1088/174296/2019/1/012043

Pramesti, D., Probosari, R. M., & Indiyanti, N. Y. (2022). Effectiveness of project based learning low carbon stem and discovery learning to improve creative thinking skills. *Journal of Innovation in Educational and Curtural Research*, *3*(3), 445–456. https://doi.org/10.46843/jiecr.v3i3.156

Puspita, A. M., Utomo, E., & Purwanto, A. (2022). Learning model based on IPA class III subject in improving students' creative thinking ability. *Jurnal Pendidikan Guru Sekolah Dasar*, 55–65. https://doi.org/10.33084/tunas.v7i2.3194

Rahma, I. F. N., Azizah, N., Sa'adah, P., & Putri, P. M. (2023). Evaluasi program pembelajaran berbasis proyek pada mata pelajaran IPA di SMP IT At Taqwa Surabaya [Evaluation of the project-based learning program in science subject at SMP IT At Taqwa Surabaya]. *Jurnal Ilmu Pendidikan*, *3*(3). https://doi.org/10.55606/sokoguru.v3i3.3034

Rati, N. W., Bagus, I., Arnyana, P., Dantes, G. R., & Dantes, N. (2023). HOTS-oriented e-project-based learning : improving 4C skills and science learning outcome of elementary school students. *International Journal of Information and Education Technology*, *13*(6). https://doi.org/10.18178/ijiet.2023.13.6.1892

Saenab, S., Yunus, S. R., & Husain, H. (2019). Pengaruh penggunaan model project based learning terhadap keterampilan kolaborasi mahasiswa pendidikan IPA [The effect of using the project-based learning model on the collaboration skills of science education students]. *Biosel: Biology Science and Education*, *8*(1), 29. https://doi.org/10.33477/bs.v8i1.844

Samsudin, A., Raharjo, T. J., & Widiasih. (2023). The effectiveness of contextual teaching learning (CTL) and problem based learning (PJBL) Models in class VI science subjects on creativity and learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9324–9331. https://doi.org/10.29303/jppipa.v9i11.5290

Şener, N., Türk, C., & Tas, E. (2015). Improving science attitude and creative thinking through science education project : a design , implementation and assessment. *Journal of Education and Training Studie 3*(4),57–67. https://doi.org/10.11114/jets.v3i4.771

States, L. (2013). Next Generation Science Standards. National Academies Press.

Stickdorn, M., Hormess, M. E., Lawrence, A., & Schneider, J. (2018). This is service design doing. O'Reilly Media, Inc.

Suprapti, S. (2021). Peningkatan hasil belajar ipa materi energi dan perubahannya dengan menggunakan metode proyek [Improving science learning outcomes on energy and its transformations using the project method]. *Journal of Education Informatic Technology and Science*, *3*(2), 51–60. https://doi.org/10.37859/jeits.v3i2.2799

Wicaksono, I., Aprilia, I., & Supraptiningsih, L. K. (2022). Penerapan asesmen formatif pembelajaran fisika dengan kuis game edukasi dan penilaian diri siswa SMA [Implementation of formative assessment in physics learning through educational quiz games and self-assessment for high school students]. *Journal Education Research and Development*, 139–150. https://doi.org/10.31537/ej.v6i2.739

Wida, E. K., Harjono, A., & Astria, F. P. (2024). Pengembangan perangkat pembelajaran berbasis proyek untuk meningkatkan hasil belajar IPA Peserta didik kelas V [Development of project-based learning materials to improve science learning outcomes of fifth-grade students]. *Jurnal Ilmiah Profesi Pendidikan*, *9*, 2207–2217. https://doi.org/10.29303/jipp.v9i3.2447

Yager, R. E. (2009). Development of student creative skills: A quest for successful science education. *October 2014*, 37–41. https://doi.org/10.1080/10400418909534315

Yildiz, C. & Guler. (2021). Exploring the relationship between creative thinking and scientific process skills of preschool children. *Thinking Skills and Creativity*, *39* (December 2020), 100795. https://doi.org/10.1016/j.tsc.2021.100795

Zaharah, & Silitonga, M. (2023). Meningkatkan kreativitas peserta didik melalui model pembelajaran berbasis proyek (project based learning) di SMP Negeri 22 Kota Jambi. [Enhancing students' creativity through project-based learning (PJBL) model at SMP Negeri 22 Jambi City]. *Biodik*, *9*(3), 139–150. https://doi.org/10.22437/biodik.v9i3.28659