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Implementing Contextual Project-Based Learning to Improve Elementary Students' Science Learning Outcomes

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ABSTRACT

Project-Based Learning (PjBL) has been widely recognized for promoting active and inquiry-based science learning. However, limited research has examined how contextual PjBL utilizing locally available materials can support elementary science learning in resource-constrained schools while simultaneously exploring students' learning outcomes, learning experiences, and teachers' implementation challenges. This study aimed to investigate the implementation of contextual PjBL in improving fifth-grade students' science learning. This study employed a mixed-methods descriptive case study conducted at an elementary school in East Nusa Tenggara, Indonesia. Participants included 20 fifth-grade students, one classroom teacher, and the school principal. The intervention consisted of a three-session contextual PjBL activity in which students constructed a simple periscope using locally available materials to learn the concept of light reflection. Data were collected through classroom observations, pre-test and post-test assessments, student response questionnaires, semi-structured interviews, and documentation. Quantitative data were analyzed descriptively using learning mastery percentages and normalized gain (N-gain), while qualitative data were analyzed thematically. The implementation of contextual PjBL created an engaging and meaningful science learning environment characterized by inquiry, collaboration, experimentation, and active participation. Students' learning mastery increased from 45% on the diagnostic pre-test to 80% on the post-test, with a moderate N-gain (0.38). Students expressed positive perceptions regarding motivation, collaboration, conceptual understanding, and confidence. Teachers also reported challenges related to project preparation, classroom management, authentic assessment, time allocation, and differences in students' abilities. The findings suggest that contextual PjBL supported by locally available materials can enhance elementary science learning by making abstract concepts more concrete and meaningful, particularly in resource-limited schools. Although the findings are limited to a single-case context, the study offers practical insights for implementing contextual, inquiry-oriented science instruction in elementary education.

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1. INTRODUCTION

Science learning in elementary schools plays a crucial role in developing students' scientific literacy, critical thinking, and problem-solving skills from an early age. In the context of 21st-century education, science instruction should not merely emphasize memorization of concepts, but also involve inquiry, experimentation, and contextual learning experiences that enable students to construct knowledge through direct interaction with real phenomena (Krajcik et al., 2023). Through inquiry-based and experiential learning, students are encouraged to observe, investigate, ask questions, test ideas, and draw conclusions scientifically. Such learning experiences are essential because elementary school students are still in the concrete operational stage, requiring meaningful and authentic activities to understand abstract scientific concepts effectively (Markula & Aksela, 2022). Therefore, science learning should be designed to connect classroom concepts with students' daily lives so that learning becomes more relevant, engaging, and meaningful.

Contextual science learning is increasingly important because many science concepts taught in elementary schools are abstract and difficult for students to visualize through conventional instruction alone. Concepts such as light reflection, refraction, energy transformation, and force often require concrete demonstrations and active exploration to facilitate conceptual understanding (Chen & Yang, 2021). In this regard, contextual learning helps students relate scientific knowledge to real-life situations and local environments, thereby enhancing motivation and conceptual retention. Previous studies have shown that contextual and hands-on science learning can improve students' scientific literacy, engagement, and learning outcomes because students actively participate in constructing understanding rather than passively receiving information (Haatainen & Aksela, 2021; Reigh et al., 2025).

One student-centered learning model that supports inquiry and contextual science learning is Project-Based Learning (PjBL). PjBL is a learning approach that places students at the center of the learning process through project activities involving investigation, collaboration, problem-solving, and product creation (Chen & Yang, 2021). In PjBL, students learn by actively exploring real-world problems and developing meaningful solutions through authentic projects. This model encourages students to integrate knowledge, skills, and creativity while simultaneously developing communication and collaboration competencies (Krajcik et al., 2023). In elementary science education, PjBL is considered effective because it provides opportunities for students to experience scientific processes directly through experimentation and project implementation (Apriansyah et al., 2024).

In addition to student-centered learning, contextualization is also an essential aspect of effective science instruction. Contextual learning enables students to connect scientific concepts with everyday experiences, local culture, and surrounding environments, making learning more concrete and understandable (Lee & Galindo, 2025). Integrating contextual elements into PjBL allows students not only to complete projects but also to understand the relevance of science in real-life situations. Contextualized PjBL supports meaningful learning because students are encouraged to apply scientific concepts in authentic contexts using accessible materials from their environment (Barak & Assal, 2024). Such integration is particularly important in elementary schools with limited facilities, where teachers must creatively utilize locally available resources to support science learning activities.

However, science learning practices in many elementary schools still tend to rely on teacher-centered instruction and textbook-oriented explanations, limiting students' opportunities to actively construct scientific understanding. Preliminary observations conducted in August 2025 at SD Negeri Kelapa Lima Kupang, East Nusa Tenggara, revealed that science learning activities were still dominated by lectures and question-answer sessions with minimal experimentation and contextual exploration. The observation was conducted through classroom observation sheets, interviews with the class teacher, and analysis of students' science achievement records. The topic observed was "The Properties of Light," particularly the concept of light reflection. Based on the school's minimum mastery criterion (KKM) of 70, only 9 out of 20 fifth-grade students (45%) achieved learning mastery on the diagnostic pre-test administered before the implementation of the learning intervention, while

11 students failed to meet the expected competency standard. These findings indicate that students experienced difficulties understanding abstract science concepts when learning was delivered primarily through verbal explanation without concrete and contextual activities.

The low learning outcomes suggest the need for innovative instructional approaches that actively engage students in meaningful scientific experiences. One potential solution is the implementation of contextual Project-Based Learning, which combines the principles of project-centered instruction with contextual learning experiences. Through contextual PjBL, students can explore scientific concepts through authentic projects using materials that are easily found in their surroundings, thereby supporting conceptual understanding despite limited school facilities (Li et al., 2021). In the context of learning light reflection, simple projects such as constructing a periscope may help students directly observe how light changes direction when reflected by mirrors. Such activities can transform abstract concepts into tangible learning experiences that are easier for elementary students to understand.

Several previous studies have demonstrated the effectiveness of PjBL in improving science learning outcomes. Krajcik et al. (2023) found that project-based science instruction significantly improved elementary students' science achievement and engagement through collaborative inquiry activities. Nevertheless, the study mainly focused on large-scale implementation in well-supported learning environments and did not specifically address contextual adaptation using locally available materials in schools with limited facilities. Similarly, Haatainen and Aksela (2021) reported that project-based STEM learning enhanced students' participation, creativity, and scientific understanding. However, their study emphasized integrated STEM practices rather than contextual science learning in elementary classrooms with limited resources. Another study by Apriansyah et al. (2024) revealed that PjBL positively influenced elementary students' science process skills and creative thinking abilities. Despite these promising findings, the study focused primarily on process skills without deeply examining how contextualization contributes to students' conceptual understanding of abstract science topics.

Based on these previous studies, it can be seen that research on PjBL in science education has been widely conducted, particularly regarding its impact on student engagement, creativity, and learning achievement. Nevertheless, limited studies have examined how contextual PjBL is implemented in elementary schools with limited learning facilities, especially using locally available materials to teach abstract science concepts such as light reflection. Most previous studies focused either on general PjBL implementation or STEM-oriented projects without specifically exploring how contextualization supports meaningful science learning in resource-constrained elementary classrooms. Therefore, this study seeks to fill this gap by investigating the implementation of contextual Project-Based Learning using simple locally available materials to improve elementary students' science learning outcomes.

The novelty of this study lies in the integration of contextual learning principles into Project-Based Learning through the utilization of locally accessible materials in teaching abstract science concepts in elementary schools with limited facilities. Unlike previous studies that mainly focused on general project implementation or technology-supported STEM learning, this study emphasizes meaningful contextual experiences through a simple periscope-making project to facilitate students' understanding of light reflection concepts. Furthermore, this research not only examines learning outcomes but also explores students' responses and teacher challenges during the implementation process, thereby providing a more comprehensive understanding of contextual PjBL practices in elementary science education.

Accordingly, this study aims to: (1) describe the implementation of contextual Project-Based Learning in improving fifth-grade students' science learning outcomes; (2) examine students' responses toward the implementation of contextual PjBL; and (3) identify the challenges faced by teachers during the implementation of contextual PjBL in elementary science learning.

2. METHODS

2.1 Research Design

This study employed a mixed-methods descriptive case study design to investigate the implementation of contextual Project-Based Learning (PjBL) in elementary science learning. The mixed-methods approach was selected because the study aimed not only to explore the learning process and classroom experiences during the implementation of contextual PjBL, but also to examine changes in students' science learning outcomes before and after the intervention. The qualitative component focused on understanding how contextual PjBL was implemented, how students responded to the learning activities, and what challenges were experienced by the teacher during classroom implementation. Meanwhile, the quantitative component was used descriptively to support the interpretation of qualitative findings through students' pre-test and post-test scores.

A descriptive case study approach was considered appropriate because the research focused on an in-depth investigation of a bounded educational context, namely the implementation of contextual PjBL in one fifth-grade classroom at SD Negeri Kelapa Lima Kupang. The study did not aim to generalize findings statistically, but rather to provide a comprehensive understanding of how contextualized project-based science learning could be implemented in an elementary school with limited learning facilities through the utilization of locally available materials.

2.2 Research Setting and Participants

The study was conducted at SD Negeri Kelapa Lima Kupang, East Nusa Tenggara, Indonesia. The school was selected purposively because preliminary observations indicated that science learning activities were still dominated by teacher-centered instruction and textbook-based explanations with limited inquiry and experimentation activities. In addition, the school represented a relevant setting for examining contextual science learning implementation in a resource-limited elementary school environment.

The participants consisted of 20 fifth-grade students of class VC, comprising 7 female students and 13 male students, one classroom teacher, and the school principal. The students were selected because they were studying the science topic of the properties of light, particularly light reflection, which requires concrete demonstration and experimentation to support conceptual understanding. The classroom teacher participated as a collaborator during the implementation process, while the school principal provided contextual information regarding school facilities and instructional support.

2.3 Preliminary Study

A preliminary study was conducted in August 2025 to identify students' initial learning conditions and instructional problems in science learning. Data were collected through classroom observations, interviews with the classroom teacher, and analysis of students' science learning records. The observation focused on classroom interaction, teaching methods, students' participation, and the use of instructional media during science lessons.

The findings showed that students experienced difficulties in understanding the topic of light reflection. Based on the school's minimum mastery criterion (KKM) of 70, only 9 out of 20 students (45%) achieved mastery on the diagnostic pre-test administered before the implementation of contextual PjBL, while the remaining 11 students did not meet the expected learning standard. These findings indicated that students had difficulty understanding abstract science concepts when instruction relied primarily on verbal explanation without contextual and hands-on learning activities.

2.4 Learning Intervention

The intervention involved the implementation of contextual Project-Based Learning through a simple periscope-making project. The project was designed to help students understand the concept of light reflection through direct observation and experimentation. The periscope project was selected because it enabled students to relate the scientific concept of light reflection to real-life applications, such as observation tools and submarines. Furthermore, the project utilized simple and locally available materials, including used cardboard, mirror pieces, glue, tape, and scissors, making it suitable for schools with limited learning facilities.

The implementation was conducted across three meetings. During the first meeting, the teacher introduced contextual trigger questions related to students' daily experiences, explained the concept of the periscope, and guided students in planning their projects. Students were divided into heterogeneous groups consisting of four to five members to support collaboration and peer interaction. The second meeting focused on the construction process. Students prepared materials, cut cardboard according to the design, positioned mirrors at 45-degree angles, assembled the periscope, and tested its functionality. During this stage, students actively discussed scientific concepts, asked questions, and revised their designs when the periscope did not function properly. The third meeting involved project testing, group presentations, and reflection activities. Students tested their periscopes in the school environment, explained the scientific principles behind light reflection, presented their project results, and reflected on their learning experiences.

2.5 Research Instruments

Five instruments were used to collect data in this study.

Table 1. Research Instruments and Data Sources

Instrument	Purpose	Data Source
Observation sheet	To observe the implementation of contextual PjBL, student participation, collaboration, and inquiry activities	Classroom learning activities
Pre-test and post-test	To measure students' science learning outcomes before and after the intervention	Students
Student response questionnaire	To identify students' perceptions, motivation, and engagement toward contextual PjBL	Students
Semi-structured interview	To explore learning experiences and implementation challenges	Teacher, students, principal
Documentation analysis	To support observational and interview findings	Lesson plans, worksheets, photos, videos, students' projects

The observation sheet was designed based on the stages of Project-Based Learning, including problem orientation, project planning, project implementation, product presentation, and reflection activities. The science learning outcomes test consisted of multiple-choice questions related to the topic of the properties of light, particularly light reflection. The pre-test was administered before the intervention to identify students' initial understanding, while the post-test was conducted after the implementation of contextual PjBL. The student response questionnaire explored students' interest, motivation, collaboration experiences, engagement, and perceived understanding of science concepts during project implementation.

Semi-structured interviews were conducted with the classroom teacher, selected students, and the school principal. Teacher interviews focused on lesson planning, classroom management, project implementation, assessment practices, and instructional challenges. Student interviews explored learning experiences and perceptions toward project-based science learning. The school principal interview provided contextual information regarding school conditions and instructional support. Documentation analysis included lesson plans, student worksheets, learning outcome records, project products, photographs, and videos collected during the learning process.

2.6 Instrument Validity and Trustworthiness

To ensure methodological rigor, the research instruments were reviewed through expert judgment involving elementary education and science education experts. The review focused on content relevance, clarity of indicators, alignment with learning objectives, and appropriateness for fifth-grade students. The trustworthiness of qualitative data was ensured through source triangulation and method triangulation. Source triangulation involved comparing information obtained from students, the classroom teacher, and the school principal. Method triangulation involved comparing findings from observations, interviews, questionnaires, tests, and documentation. Member checking was also conducted by confirming interview summaries with participants to ensure the accuracy of interpretations. In addition, field notes and documentation records were maintained systematically to support the dependability and confirmability of the findings.

2.7 Data Collection Procedure

Data collection was conducted in four stages.

Table 2. Research Procedure

Stage	Activities
Preliminary Study	Classroom observation, teacher interview, diagnostic pre-test
Planning	Preparation of lesson plans, project scenarios, instruments, and learning materials
Implementation	Conducting contextual PjBL through periscope-making activities across three meetings
Evaluation	Post-test, student questionnaire, interviews, and documentation collection
Data Analysis	Quantitative descriptive analysis and qualitative thematic analysis

The implementation of contextual PjBL during classroom learning is described in Table 3.

Table 3. Stages of Contextual Project-Based Learning Implementation

Meeting	Activities	Learning Focus
Meeting 1	Trigger questions, project introduction, group formation, and project planning	Understanding the concept of light reflection
Meeting 2	Periscope construction, experimentation, and group discussion	Inquiry, collaboration, and problem-solving
Meeting 3	Product testing, group presentation, and reflection	Conceptual understanding and communication skills

During the implementation process, the researcher acted as a participant observer while the classroom teacher facilitated learning activities. Observational field notes were recorded during each meeting to capture classroom interaction, student participation, and learning dynamics.

2.8 Data Analysis

Quantitative data from the pre-test and post-test were analyzed descriptively using students' individual scores, mean scores, score differences, and percentages of learning mastery. Students were categorized as achieving mastery if their scores reached or exceeded the school's *KKM* score of 70. The percentage of learning mastery was calculated by dividing the number of students achieving mastery by the total number of students. Qualitative data obtained from observations, interviews, open-ended questionnaire responses, and documentation were analyzed using the interactive analysis model consisting of data condensation, data display, and conclusion drawing. During data condensation, relevant information related to classroom implementation, student responses, and teacher challenges was selected, coded, categorized, and simplified. Data were then organized into narrative descriptions and thematic displays to facilitate interpretation. Finally, conclusions were drawn by identifying recurring patterns, comparing findings across data sources, and interpreting the findings in relation to the research objectives.

The integration of quantitative and qualitative findings was conducted during the interpretation stage. Quantitative data provided evidence of changes in students' learning outcomes, while qualitative findings explained how contextual PjBL influenced students' engagement, conceptual understanding, and classroom learning experiences.

Table 4. Data Analysis Techniques

Data Type	Analysis Technique
Pre-test and post-test scores	Descriptive statistics and N-gain analysis
Observation data	Thematic analysis
Interview data	Coding and thematic categorization
Questionnaire responses	Descriptive interpretation
Documentation	Triangulation support

2.9 Ethical Considerations

Prior to the study, permission was obtained from the school principal and classroom teacher. Students participated as part of classroom learning activities, and all collected data were used solely for research purposes. To maintain confidentiality, students' identities were anonymized in all research reports and publications.

3. FINDINGS AND DISCUSSION

3.1 Findings

3.1.1 Implementation of Contextual Project-Based Learning in Elementary Science Learning

The implementation of contextual Project-Based Learning (PjBL) in science learning was conducted systematically through three major stages: planning, implementation, and evaluation. The learning activities focused on the topic of light reflection through a simple periscope-making project using locally available materials. The findings indicate that contextual PjBL not only improved students' science learning outcomes but also promoted active participation, collaborative learning, inquiry behavior, and meaningful conceptual understanding.

a. Planning Stage of Contextual PjBL

The planning stage was conducted collaboratively between the researcher and the classroom teacher prior to classroom implementation. At this stage, lesson plans, student worksheets, project scenarios, assessment instruments, and observation sheets were developed based on the principles of contextual Project-Based Learning. The learning objectives focused on students' ability to explain the concept of light reflection and apply the concept through the construction of a simple optical instrument.

The periscope project was selected because it enabled students to directly observe the principle of light reflection in authentic situations. The project was intentionally designed using simple and locally available materials such as used cardboard, mirror pieces, glue, tape, and scissors to accommodate the school's limited learning facilities. This contextualization strategy was intended to help students connect abstract science concepts with real-life experiences and familiar objects from their surrounding environment.

The classroom teacher explained that the project was selected because it could simplify students' understanding of light reflection through direct experimentation: "The periscope project helped students understand light reflection more concretely because they could directly observe how reflected light changes direction." (Teacher Interview, November 2025). The planning stage also involved organizing students into heterogeneous collaborative groups consisting of four to five members to facilitate peer interaction, inquiry, and collaborative problem-solving during project implementation.

b. Implementation Stage of Contextual PjBL

The implementation stage was conducted across three classroom meetings. Throughout the learning process, students demonstrated active engagement in inquiry, experimentation, discussion, and collaborative project completion.

First Meeting: Problem Orientation and Project Planning.

The first meeting focused on contextual problem orientation and project planning activities. The teacher began the lesson by presenting trigger questions related to students' daily experiences with mirrors and observation tools. Students were encouraged to discuss situations in which mirrors are used to observe hidden objects and predict how light changes direction after reflection. During this stage, students actively responded to the teacher's questions and shared experiences related to mirrors and visual observation. The teacher then introduced the periscope as a simple optical instrument utilizing the principle of light reflection. Students observed a demonstration of the periscope and discussed how reflected light enables hidden objects to become visible. After the introduction, students worked collaboratively within their groups to identify required materials, discuss project designs, and plan the construction process. Observation data indicated that students demonstrated curiosity, enthusiasm, and active participation during the planning activities. Several students asked questions regarding mirror placement, light direction, and the purpose of using a 45-degree mirror angle inside the periscope. The teacher acted as a facilitator by encouraging inquiry, guiding group discussion, and providing scaffolding when students experienced difficulties understanding scientific concepts.

Second Meeting: Periscope Construction and Inquiry Activities

The second meeting focused on constructing the periscope and conducting inquiry-based experimentation. Students prepared tools and materials before beginning the assembly process. The activities included cutting cardboard according to the project design, positioning mirrors at 45-degree angles, assembling the structure, and testing the functionality of the periscope. Observation findings revealed that students were highly engaged during the construction process. Students actively discussed mirror placement, experimented with different angles, and revised their designs when the reflected image was unclear. The collaborative learning environment encouraged students to exchange ideas, solve problems collectively, and support peers experiencing difficulties.

Several groups initially failed to produce clear reflected images because the mirrors were not properly positioned. Rather than directly correcting the mistakes, the teacher encouraged students to investigate the problem independently by observing how light moved through the periscope. This process stimulated inquiry behavior, collaborative problem-solving, and critical thinking. One student explained: "Initially, the reflected image was unclear because the mirror angle was not properly positioned. After adjusting the mirror placement, the image became visible." (Student 3, Interview, November 2025). The findings suggest that contextual PjBL promoted experiential learning because students learned scientific concepts through direct experimentation, collaborative inquiry, and iterative problem-solving processes.

Third Meeting: Product Testing, Presentation, and Reflection

The third meeting focused on testing the completed periscopes, presenting project results, and conducting reflection activities. Students tested their periscopes in the school environment by observing distant objects blocked by walls and other obstacles. During the testing process, students demonstrated excitement and curiosity when the periscope functioned successfully. One student stated: "Using the periscope made it easier to understand how light reflection works because we could directly observe the reflected image." (Student 7, Interview, November 2025). Each group then presented its project in front of the class. The presentations included explanations of the construction process, challenges encountered during implementation, scientific principles behind the periscope, and the relationship between the project and the concept of light reflection. Observation data further showed that students became more confident in expressing ideas and explaining scientific concepts after participating in project activities. During reflection activities, students stated that learning science through projects was more interesting and easier to understand compared to conventional lecture-based learning. The reflection process also revealed that contextual and hands-on learning experiences helped students connect abstract science concepts with authentic real-world applications.

3.1.2 Improvement of Students' Science Learning Outcomes

The quantitative findings indicate a substantial improvement in students' science learning outcomes after the implementation of contextual PjBL. Prior to the intervention, only 9 out of 20 students (45%) achieved the school's minimum mastery criterion (KKM = 70) on the diagnostic pre-test. After the implementation of contextual PjBL, the number of students achieving mastery increased to 16 students (80%).

Table 5. Students' Science Learning Outcomes Before and After the Intervention

Category	Pre-test	Post-test
Students achieving mastery	9 students	16 students
Students not achieving mastery	11 students	4 students
Percentage of mastery	**45%**	**80%**

The increase in learning mastery indicates that contextual PjBL contributed positively to students' conceptual understanding of light reflection. Students were able to visualize abstract concepts more concretely through direct observation, experimentation, and manipulation of learning materials. To provide a clearer description of students' learning improvement, descriptive statistical analysis was conducted on students' pre-test and post-test scores.

Table 6. Descriptive Statistics of Students' Learning Outcomes

Statistic	Pre-test	Post-test
Mean Score	71.4	82.3
Highest Score	92	96
Lowest Score	40	60
Students Achieving Mastery	9	16
Mastery Percentage	**45%**	**80%**

The descriptive statistics show that students' average scores improved after the implementation of contextual PjBL. In addition, the increase in the lowest score from 40 to 60 indicates that lower-achieving students also experienced conceptual improvement during the learning process. To strengthen the interpretation of learning improvement, normalized gain analysis (N-gain) was also conducted.

Table 7. N-Gain Analysis of Students' Learning Outcomes

Mean Pre-test	Mean Post-test	N-Gain Score	Category
71.4	82.3	0.38	Moderate

The N-gain analysis indicates that the implementation of contextual PjBL resulted in a moderate improvement in students' science learning outcomes. These findings suggest that contextual project activities and inquiry-based experimentation supported students' conceptual understanding of light reflection more effectively than conventional instruction. Observation findings also revealed increased participation, confidence, collaboration, and engagement during learning activities. Students became more active during discussions, more willing to ask questions, and more confident when presenting project results.

3.1.3 Students' Responses toward Contextual PjBL

The findings from questionnaires, observations, and interviews indicate that students responded positively toward the implementation of contextual PjBL. Most students stated that science learning through project activities was more interesting, enjoyable, and easier to understand than conventional learning methods. Students particularly appreciated the opportunity to directly construct learning media and experiment with scientific concepts. The use of simple materials from their surrounding environment also increased students' sense of familiarity and accessibility toward science learning activities. One student stated: "I enjoyed learning science by making the periscope because we could directly practice and understand the lesson." (Student 5, Interview, November 2025). Another student explained: "Working collaboratively in groups made learning easier because we could help each other solve problems during the project activities." (Student 8, Interview, November 2025). Observation data further showed that students became more active during discussions, more confident during presentations, and more willing to ask questions during inquiry activities.

Table 8. Students' Responses Toward Contextual PjBL

Indicator	Students' Responses
Interest in science learning	Very positive
Motivation during learning	Increased
Participation in classroom discussion	More active
Collaboration with peers	Improved
Understanding of light reflection concepts	Easier to understand
Confidence during presentations	Increased

Overall, the findings indicate that contextual PjBL created a more engaging, interactive, and meaningful learning environment for elementary science learning.

3.1.4 Teacher Challenges in Implementing Contextual PjBL

Despite the positive learning outcomes, the implementation of contextual PjBL also presented several challenges for the classroom teacher. The first challenge involved designing contextual projects aligned with science learning objectives while remaining feasible within limited classroom facilities. The teacher reported that preparing project scenarios and learning materials required considerable time and careful planning.

The second challenge involved differences in students' academic abilities and collaboration skills. Some students adapted quickly to inquiry and project activities, while others required intensive guidance and scaffolding during group work. The third challenge related to time management. Project-based learning activities required longer instructional time compared to conventional teaching methods, particularly during construction and experimentation processes. The fourth challenge involved limited learning resources and supporting facilities. Although the project utilized locally available materials, the teacher still needed to creatively adapt learning activities to available classroom conditions. The teacher explained: "Contextual project-based learning created a more active and engaging classroom atmosphere, but it required more preparation time and careful classroom management." (Teacher Interview, November 2025).

Finally, the teacher reported challenges related to authentic assessment because evaluation was not limited to the final project product but also involved assessing participation, collaboration, inquiry processes, and conceptual understanding throughout the learning activities.

Table 9. Teacher Challenges During Contextual PjBL Implementation

Challenge	Description
Project preparation	Requires extensive planning and preparation time
Differences in students' abilities	Some students require intensive guidance
Time management	Project activities require longer instructional duration
Limited facilities	Learning resources and materials are limited
Authentic assessment	Difficult to assess both process and product simultaneously

Overall, the findings indicate that although contextual PjBL implementation required substantial preparation and instructional adaptation, the approach contributed positively to students' science learning experiences, engagement, and conceptual understanding in elementary science classrooms with limited facilities.

3.2 Discussion

The findings of this study demonstrate that the implementation of contextual Project-Based Learning (PjBL) contributed positively to elementary students' science learning outcomes, learning engagement, collaboration, inquiry behavior, and conceptual understanding of light reflection. The integration of contextual learning principles with project-based activities enabled students to experience science learning through direct experimentation, authentic problem-solving, and meaningful interaction with real-world phenomena. These findings reinforce the argument that elementary science learning should move beyond teacher-centered instruction toward inquiry-oriented and experiential learning approaches that actively involve students in knowledge construction.

The improvement in students' science learning outcomes after the implementation of contextual PjBL indicates that project-based inquiry activities can facilitate deeper conceptual understanding of abstract science concepts. The increase in mastery learning from 45% to 80%, accompanied by a moderate N-gain score, suggests that students benefited from direct experimentation and contextual learning experiences during the periscope-making project. These findings support previous studies emphasizing that project-based science instruction improves students' academic achievement because students actively construct understanding through investigation and experimentation rather than passively receiving information (Syahlan et al., 2023; Luo et al., 2024).

The use of a simple periscope as a contextual project also played a significant role in helping students visualize the concept of light reflection more concretely. Through direct manipulation of mirrors and observation of reflected images, students were able to connect theoretical explanations with authentic scientific experiences. This finding aligns with constructivist learning theory, which argues that conceptual understanding develops more effectively when learners actively interact with physical phenomena and construct meaning from direct experiences. In elementary science learning, hands-on experimentation is particularly important because students at the concrete operational stage require observable and contextual learning experiences to understand abstract concepts effectively. Similar findings were reported by Tas and Bolat (2025), who found that inquiry-oriented science instruction in primary classrooms significantly enhanced students' conceptual understanding and scientific reasoning through authentic learning experiences.

The findings further indicate that contextualization strengthened the effectiveness of Project-Based Learning implementation. The utilization of locally available materials such as cardboard, mirrors, glue, and tape made science learning more accessible and meaningful for students. Contextual learning allowed students to connect scientific concepts with familiar objects and situations from their surrounding environment, thereby increasing engagement and facilitating conceptual retention. This result supports the findings of Jamaludin et al. (2023), who emphasized that contextualized STEAM and project-based activities improve scientific literacy because students perceive science as relevant to their daily experiences. Similarly, Barak and Assal (2024) argued that contextual adaptation is a key factor influencing the effectiveness of project-based learning because meaningful contexts enhance students' cognitive engagement and motivation.

The collaborative nature of contextual PjBL also contributed to students' social interaction and communication skills. During project construction and experimentation, students worked collaboratively to solve problems, exchange ideas, and revise project designs. Observation findings revealed that students became more active during discussions and more confident during presentations after participating in the project activities. These findings are consistent with social constructivist perspectives, which emphasize that knowledge is socially constructed through interaction and collaborative inquiry. Similar findings were reported by Cevik et al. (2025), who found that collaborative project-based STEM learning significantly improved students' motivation, self-efficacy, and communication skills.

The inquiry process observed during the implementation stage further illustrates how contextual PjBL encouraged higher-order thinking and scientific reasoning. Rather than directly providing solutions when the periscopes failed to function properly, the teacher encouraged students to independently investigate the causes of the problem and revise the mirror positions through experimentation. This instructional strategy promoted inquiry behavior, critical thinking, and reflective problem-solving. Such findings support the work of Li et al. (2021), who reported that project-based inquiry learning enhances students' analytical thinking because learners engage in iterative experimentation and active exploration during project completion.

Another important finding of this study concerns students' positive responses toward contextual PjBL. Students perceived science learning through project activities as more interesting, enjoyable, and easier to understand compared to conventional lecture-based instruction. The opportunity to directly construct learning media and experiment with scientific concepts increased students' curiosity, motivation, and engagement during learning activities. These findings are in line with Papadakis et al. (2025), who emphasized that active project-based learning environments create more engaging learning experiences because students become directly involved in meaningful exploration and discovery activities. Similar results were also identified by Sausan et al. (2025), who found that project-based learning promotes creativity and curiosity by encouraging students to actively participate in contextual problem-solving activities.

The positive learning atmosphere observed during the implementation of contextual PjBL also demonstrates the importance of authentic learning experiences in elementary science education. Students became more confident in explaining scientific concepts because they directly experienced how scientific principles operate in practical situations. This experiential learning process supports the development of deeper conceptual understanding and long-term retention. In line with these findings, Manz et al. (2024) argued that combining hands-on and minds-on science learning activities strengthens elementary students' conceptual understanding because students simultaneously engage in physical experimentation and cognitive reflection.

The findings additionally suggest that contextual PjBL supports the development of science process skills and inquiry competencies. During the project activities, students observed, predicted, experimented, revised, and reflected on scientific phenomena related to light reflection. These activities reflect authentic scientific practices commonly emphasized in contemporary science education frameworks. Similar conclusions were reported by Aprilianti et al. (2025), who found that STEM-oriented project-based learning improved students' scientific literacy and inquiry competencies through active experimentation and contextual investigation activities.

Despite these positive outcomes, the implementation of contextual PjBL also presented several instructional challenges. The teacher reported difficulties related to project preparation, classroom management, time allocation, authentic assessment, and differences in students' abilities. These findings suggest that successful implementation of contextual PjBL requires substantial pedagogical preparation and instructional flexibility. Project-based learning is inherently more complex than conventional instruction because teachers must simultaneously facilitate inquiry, monitor collaboration, manage classroom dynamics, and assess both learning processes and final products. Similar implementation challenges were identified by Nasharuddin et al. (2025), who reported that contextual project-based learning often requires adaptive instructional planning and creative utilization of local resources, particularly in schools with limited facilities.

The challenge related to authentic assessment is particularly important in project-based science learning. The teacher reported difficulty assessing not only the final project product but also students' collaboration, inquiry participation, problem-solving processes, and conceptual understanding throughout the learning activities. This finding reflects broader challenges in project-based education, where assessment must capture multidimensional learning outcomes rather than merely measuring factual recall. Saad and Zainudin (2022) similarly argued that project-based STEM learning requires more comprehensive and authentic assessment systems capable of evaluating both cognitive and process-oriented competencies.

The findings of this study also demonstrate that contextual PjBL can be effectively implemented even in elementary schools with limited learning facilities. By utilizing simple locally available materials, the teacher successfully created meaningful science learning experiences without relying on expensive laboratory equipment or advanced technology. This finding contributes to the growing body of literature emphasizing the importance of contextual adaptation and local resource utilization in improving educational quality in under-resourced schools. Lee and Galindo (2025) similarly emphasized that contextualized project-based STEM learning can provide equitable access to meaningful science learning opportunities for students across diverse educational settings.

From a theoretical perspective, this study reinforces constructivist and experiential learning theories by demonstrating that students learn science more effectively when they actively engage in authentic inquiry, experimentation, and collaborative problem-solving activities. Contextual PjBL enabled students to construct conceptual understanding through direct interaction with scientific phenomena rather than passive memorization. The findings further support the argument that contextualization enhances the effectiveness of project-based learning because students are more motivated and cognitively engaged when learning activities are connected to real-life experiences.

This study also contributes to the literature by demonstrating how contextual PjBL may be adapted to elementary schools with limited facilities through the use of locally accessible materials. Previous studies have frequently examined project-based learning within technologically supported or STEM-oriented educational contexts. In contrast, this study highlights the pedagogical potential of low-cost contextual science projects for supporting meaningful conceptual understanding in resource-limited classrooms. The findings therefore provide practical implications for elementary teachers seeking to implement inquiry-oriented science learning despite infrastructural limitations.

Overall, the discussion findings suggest that contextual Project-Based Learning represents a promising instructional approach for improving elementary students' science learning outcomes, engagement, inquiry behavior, and conceptual understanding. Although implementation requires careful planning, instructional adaptation, and authentic assessment strategies, contextual PjBL provides meaningful opportunities for students to experience science as an active process of inquiry and discovery closely connected to their everyday lives.

4. CONCLUSION

This study shows that contextual Project-Based Learning (PjBL) can strengthen elementary science learning by integrating inquiry, experimentation, collaboration, and real-world experiences. The findings indicate that connecting science concepts to familiar contexts and accessible local materials helps students understand abstract ideas more concretely. The simple periscope-making project demonstrates that meaningful science learning does not always require advanced laboratory facilities, but depends on teachers' ability to design contextual, hands-on, and inquiry-oriented activities that promote curiosity, scientific reasoning, communication, collaboration, and student confidence.

Theoretically, this study contributes to contextual and project-based science education by showing how low-cost, locally relevant projects can support meaningful learning in resource-limited elementary classrooms. Practically, it suggests that teachers need careful project planning, adaptive classroom management, authentic assessment, and professional support to implement contextual PjBL effectively. However, the study is limited by its single-classroom context and small number of participants. Future research should examine the long-term effects of contextual PjBL across different schools, science topics, and student populations, and explore its integration with digital learning, STEM approaches, or culturally responsive science instruction.

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