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Implementation of a project-based scientific approach in IPAS learning for 5th-grade elementary school student

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Abstract: This study aims to analyze the implementation of the Project-Based Scientific Approach (PjBL-SA) in science and social studies learning and its influence on elementary students' critical thinking skills. Conducted in Grade V of SDN 013 Tana Tidung, this mixed-method research integrated qualitative observations and quantitative testing. Data were gathered through classroom observations, questionnaires, critical thinking tests, and interviews with teachers and students. The results showed that the PjBL-SA model effectively enhanced students' learning engagement and conceptual understanding. Students reported increased motivation (78%), better comprehension through practice (82%), and higher enjoyment in group learning (75%). Statistical analysis using a paired t-test demonstrated a significant improvement in critical thinking performance (pretest = 62.3; posttest = 78.9; t = 6.24; $p < 0.05$), with the highest gain in the inference indicator (0.42). Pearson correlation analysis further indicated a strong positive relationship between project involvement and critical thinking ($r = 0.63$; $p < 0.01$). These findings confirm that PjBL-SA fosters students' critical, creative, and collaborative abilities, making it a relevant and innovative instructional strategy for IPAS in elementary education.

Keywords: Critical thinking skills, elementary school, project-based scientific approach

Abstrak: Penelitian ini bertujuan untuk menganalisis penerapan *Project-Based Scientific Approach* (PjBL-SA) dalam pembelajaran Ilmu Pengetahuan Alam dan Sosial serta pengaruhnya terhadap keterampilan berpikir kritis siswa sekolah dasar. Penelitian dilaksanakan di kelas V SDN 013 Tana Tidung dengan menggunakan desain *mixed-method* yang mengombinasikan pendekatan kualitatif dan kuantitatif. Data dikumpulkan melalui observasi kelas, angket, tes berpikir kritis, serta wawancara dengan guru dan siswa. Hasil penelitian menunjukkan bahwa penerapan PjBL-SA mampu meningkatkan keterlibatan dan pemahaman konsep siswa. Siswa menunjukkan peningkatan motivasi belajar (78%), pemahaman konsep melalui praktik (82%), dan kesenangan dalam belajar kelompok (75%). Analisis *paired t-test* menunjukkan peningkatan signifikan dalam keterampilan berpikir kritis (pretest = 62,3; posttest = 78,9; t = 6,24; p < 0,05) dengan peningkatan tertinggi pada indikator inferensi (gain = 0,42). Analisis korelasi Pearson juga menunjukkan hubungan positif yang kuat antara keterlibatan dalam proyek dan keterampilan berpikir kritis (r = 0,63; p < 0,01). Temuan ini menegaskan bahwa PjBL-SA berkontribusi signifikan terhadap pengembangan kemampuan berpikir kritis, kreatif, dan kolaboratif siswa, sehingga relevan sebagai strategi pembelajaran inovatif untuk IPAS di sekolah dasar.

Kata kunci: Keterampilan berpikir kritis, sekolah dasar, pendekatan ilmiah berbasis proyek

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INTRODUCTION

Twenty-first-century education demands a paradigm shift from a teacher-centered to a student-centered learning approach. This transformation requires learning processes that empower students to actively construct meaning from experience, not merely receive information. This shift is not just pedagogical but also philosophical, as it emphasizes the student's active role in constructing knowledge through meaningful experiences. Trilling and Fadel (2009) affirm that to thrive in a rapidly changing world, students must possess

21st-century skills summarized as the 4Cs: critical thinking, creativity, collaboration, and communication. Among these, critical thinking is seen as the main foundation that enables students to analyze information, solve problems, and make rational decisions (Facione & Gittens, 2015). Critical thinking functions as a metacognitive competence that supports learning autonomy and lifelong learning capabilities. International research also shows that implementing student-centered pedagogy is more effective in improving learning outcomes and higher-order thinking skills (Iftiah et al., 2023; Jensen, 2019; Nunaki et al., 2023; Sartika et al., 2023).

In the Indonesian context, one effort to realize 21st-century learning is through the Natural and Social Sciences (IPAS) subject introduced in the 2013 Curriculum. IPAS is an integrated subject that combines science and social studies, encouraging students to observe, question, and understand natural and social phenomena holistically through inquiry and contextual exploration. Nevertheless, several studies have revealed that IPAS learning practices in elementary schools still tend to be dominated by textbooks and lecture methods, with limited student involvement in inquiry or exploration activities (Nasir et al., 2024; Retnawati et al., 2017; Wulandari, 2023). This condition has led to students' critical thinking skills not developing optimally. Therefore, the implementation of more engaging and authentic learning models is necessary to enhance students' participation and reasoning skills in IPAS learning.

To address this weakness, the Ministry of Education and Culture formulated the scientific approach as the core of the 2013 Curriculum. This approach includes five learning stages: observing, questioning, gathering information, reasoning/associating, and communicating (Kemendikbud, 2016). Conceptually, the scientific approach is believed to activate students and encourage the development of cognitive skills through scientific reasoning. However, in practice, several obstacles are still found, such as limited teacher readiness, rigid learning materials, and a lack of integration with students' real-life experiences (Dewi et al., 2023; Hakim et al., 2025; Hama & Amin, 2025; Thenu et al., 2023). These constraints indicate that the scientific approach needs to be strengthened by a complementary model that enhances contextual understanding, motivation, and collaboration among students.

One model that is believed to be relevant is Project-Based Learning (PjBL), a learning model that positions students as active problem-solvers and decision-makers in real-world contexts. PjBL challenges students to conduct investigations, design solutions, and present their results in collaborative work (Bell, 2010; Thomas, 2000). Various studies show that PjBL can increase students' motivation, creativity, perseverance, and critical thinking skills (Anisa et al., 2023; Novitasari et al., 2024; Pratiwi et al., 2025; Tekir, 2022). The combination of PjBL with a scientific approach, hereafter referred to as the Project-Based Scientific Approach (PjBL-SA), integrates structured inquiry with authentic project activities that reflect real-life challenges.

Nevertheless, the implementation of a project-based scientific approach in elementary schools still faces challenges, especially in 3T (disadvantaged, frontier, outermost) regions like Tana Tidung Regency, North Kalimantan. Teachers often encounter difficulties in designing interdisciplinary projects, managing classroom logistics, and facilitating inquiry for students with diverse learning needs (Dewanti et al., 2020; Hakim et al., 2025). In addition, contextual limitations and resource constraints often hinder the application of innovative models such as PjBL-SA in rural schools. This condition shows a gap between curriculum policy and field practice, necessitating empirical research that documents in detail how this strategy can be adapted to the elementary school context (Amini et al., 2019; Creswell & Clark, 2018). The integration of the scientific approach with PjBL offers a dual advantage: the structured inquiry skills from the scientific approach and the real-world context provided by PjBL projects. This synthesis promotes both procedural understanding and conceptual depth, while nurturing creativity and collaboration. Previous studies have shown that this model effectively enhances students' critical thinking, motivation, and engagement (Tiwow et al., 2023). The implementation of PjBL-SA is also in line with the Merdeka Curriculum, which emphasizes project-based learning to develop students' holistic competencies (Faizal & Ichsan, 2025; Oktaviani, 2024).

Therefore, this study aims to analyze the implementation of the Project-Based Scientific Approach (PjBL-SA) in IPAS learning for fifth-grade students at SDN 013 Tana Tidung. Specifically, it seeks to (1) describe how PjBL-SA is designed and implemented in classroom learning; (2) explore teachers' and students' perceptions of the model; (3) examine differences in students' critical thinking skills before and after the implementation; and (4) explain the relationship between students' project engagement and the development of their critical thinking abilities. Through these objectives, the study is expected to provide both practical insights for teachers in enhancing IPAS instruction and theoretical contributions to the field of innovative learning models in elementary education.

METHOD

This study employed a mixed-methods approach combining qualitative and quantitative designs to obtain a comprehensive understanding of the implementation of the Project-Based Scientific Approach (PjBL-SA) in IPAS learning and its impact on students' critical thinking skills. The qualitative component focused on describing teacher roles, classroom activities, and student interactions throughout the PjBL-SA process, while the quantitative component adopted a one-group pretest–posttest experimental design to measure the improvement of students' critical thinking skills before and after the intervention.

Data collection techniques

Classroom observations were conducted continuously during the teaching and learning process to capture both teacher and student activities, particularly those aligned with the stages of the scientific approach observing, questioning, gathering data, reasoning, and communicating. The observation instrument was adapted from Sudjana, (2010), and designed to record qualitative indicators of engagement and interaction. Observations were supported by field notes and photographs to provide contextual evidence. Semi-structured interviews were conducted with the teacher and selected students after the completion of the learning cycle. Teacher interviews explored planning strategies, encountered challenges, and reflections on classroom practices, while student interviews examined perceptions of learning activities and their influence on critical thinking development. All interviews were audio-recorded, transcribed verbatim, and analyzed thematically to ensure credibility and consistency. Supporting documents such as student project outputs (e.g., posters, presentations, and reports), lesson plans, learning worksheets, and photographs of classroom activities were collected to triangulate qualitative findings and enrich contextual understanding (Sugiyono, 2018).

A test instrument consisting of eight open-ended items was developed to assess students' critical thinking skills, referring to indicators proposed by Facione and Gittens (2015): clarification, inference, evaluation, and decision-making. Content validity was verified by three experts—two in mathematics education and one in primary education resulting in an Aiken's V index of 0.82, categorized as high validity**.** Internal consistency testing using Cronbach's Alpha produced a coefficient of 0.81, indicating good reliability. The test items showed moderate to high discrimination power, ensuring adequate sensitivity to measure students' cognitive development. A 12-item Likert-scale questionnaire was used to assess students' perceptions of motivation, collaboration, and understanding during the PjBL-SA implementation. Expert validation yielded V = 0.79, and Cronbach's Alpha = 0.84, confirming high reliability**.** These data complemented the qualitative findings on student engagement and response.

Data analysis

Qualitative data were analyzed using Miles (1994), interactive model, which includes data reduction, data display, and conclusion drawing. Thematic coding was conducted on observation sheets, interview transcripts, and documentation to identify recurring patterns related to PjBL-SA implementation and student critical thinking behaviors. Quantitative data were analyzed using a paired-sample t-test (for normally distributed data) or the Wilcoxon signed-rank test (for non-parametric data) to determine the significance of improvement between pretest and posttest results. Descriptive statistics were also used to present mean scores, gain values, and standard deviations.

Research procedures

The research followed five systematic stages:

1. Pre-observation, to identify the existing learning conditions and teacher readiness.
2. Collaborative planning, involving co-design of a project-based IPAS learning unit that integrated local environmental issues.
3. Implementation of PjBL-SA over two weeks, comprising observation, data collection, and student project execution.
4. Administration of pretest and posttest to assess students' critical thinking skills.
5. Reflection and evaluation, conducted through interviews and document analysis to review the implementation process.

Validity and research ethics

Qualitative validity was ensured through data triangulation (observation, interview, documentation) and member checking with participants to confirm accuracy. Quantitative validity was maintained through expert validation and reliability testing of instruments prior to use. Ethical clearance was obtained from the local education authority, and informed consent was secured from the school, teacher, students, and parents. All procedures adhered to ethical standards for educational research involving minors, in line with guidelines from (Sugiyono, 2018).

RESULTS AND DISCUSSION

Implementation of the project-based scientific approach (PjBL-SA) in IPAS learning

Based on documentation from lesson plans and student worksheets, the teacher designed a project on the theme of Environmental Conservation and Waste Recycling. The lesson plans incorporated the five stages of the scientific approach observing, questioning, experimenting, associating, and communicating which align with Kolb (2014), experiential learning cycle emphasizing learning through experience and reflection. The analysis of instructional documents indicated that the completeness score for planning reached 87% (very good category). The strongest component was the clarity of learning objectives (100%), while the relatively weaker aspect was the completeness of the project assessment instruments (75%).

Over four meetings, students were divided into five groups of 5–6 people. Activities began with observing the school environment and documenting waste types, followed by designing prototypes of eco-friendly trash cans. This process reflected Dewey (1938) principle of learning by doing, in which students construct knowledge through authentic inquiry. The overall average percentage of student engagement reached 82% (high category). The most active aspects were data collection (91%) and group discussion (88%), while the lowest was asking critical questions (67%). This pattern aligns with the findings of Liu & Pásztor, (2022), who reported that the development of questioning and inquiry skills requires consistent scaffolding within PjBL settings.

The teacher's role in this process functioned primarily as a facilitator, guiding students through reflective questioning and feedback. Analysis showed that the teacher posed an average of 3–4 guiding questions in each meeting. This practice supports Bell (2010), concept that teachers in PjBL act as scaffolding agents who nurture students' inquiry rather than deliver direct instruction. Interview data also revealed that the teacher perceived their role as a "motivator and guide" rather than a "material provider." However, challenges were noted in time management due to students' high enthusiasm during discussions. Similar findings were highlighted by Aswan et al. (2024), who observed that logistical management and time allocation remain critical obstacles in implementing project-based learning, especially in rural and under-resourced schools.

Each group presented its project outcomes in class. The products included campaign posters, prototype trash cans, and short written reports. The presentation rubric, which assessed communication, content, and collaboration, yielded an average score of 83/100 (good category). The highest achievement was in collaboration (88%), while the lowest was in clarity of communication (78%), indicating that students still needed practice in public speaking and scientific explanation. These findings are consistent with Vygotsky (1978) social constructivist theory, which emphasizes that collaborative dialogue and peer interaction serve as key mediators for cognitive and linguistic growth.

The implementation of PjBL-SA in IPAS learning produced various tangible products reflecting students' active involvement and critical thinking skills. One group created a simple water filter prototype made from recycled materials as a solution to water pollution observed in their community. This project illustrates Thomas (2000) view that authentic tasks within PjBL strengthen problem-solving and conceptual understanding. Moreover, hands-on experiences like these have been proven to enhance motivation and learning transfer. Through this process, students not only understood the concept of filtration but also practiced scientific inquiry through experimentation.

Another group designed an environmental awareness poster depicting the interdependence between living organisms and their ecosystems. This activity encouraged students to communicate scientific ideas creatively and fostered environmental responsibility, resonating with Trilling and Fadel, (2009) 4Cs framework emphasizing critical thinking, collaboration, creativity, and communication as key competencies in 21st-century education. Recent meta-analyses also confirm that PjBL has a significant positive impact on these higher-order skills (Liu & Pásztor, 2022).

Overall, both products demonstrated that project-based learning grounded in scientific inquiry enables students to integrate conceptual knowledge with real-world applications. The implementation of PjBL-SA not only strengthened understanding of IPAS concepts but also developed critical thinking, creativity, collaboration, and communication skills. These findings align with evidence from meta-analytic studies indicating that PjBL yields a medium-to-high effect size (SMD ≈ 0.44–0.68) in improving students' critical and creative thinking.

In conclusion, the integration of the project-based approach with scientific inquiry provided a contextualized learning experience that bridged theory and practice. Students were able to connect academic concepts with their daily lives, making the learning process more meaningful, collaborative, and reflective. Such results affirm that PjBL-SA is an effective pedagogical model aligned with the vision of the *Merdeka Curriculum*, which emphasizes autonomy, contextual learning, and the holistic development of learners.

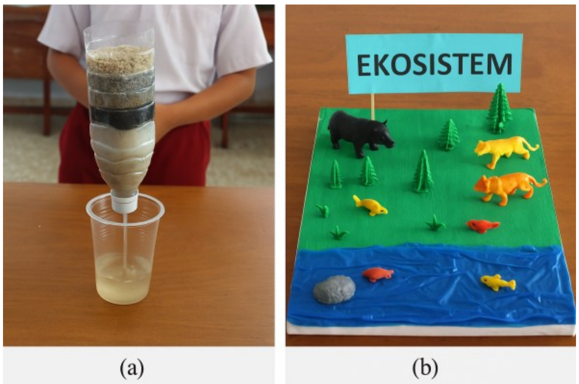

Fig. 1. (a) Recycled water filter project; (b) Environmental awareness poster

Reflection was carried out through learning journals written by students. The analysis of the instrument was in the form of thematic coding of 26 student journals. The results of the analysis showed that (1) 76% of students wrote that they "better understood how to protect the environment through a real project"; (2) 69% of students stated that learning was easier because it was "direct practice"; (3) However, 15% of students admitted to having difficulty dividing tasks within the group.

Based on the results of observations, interviews, and documentation, the implementation of PjBL-SA in the 5th grade at SDN 013 Tana Tidung showed that students were actively involved in every stage of learning, from planning and project implementation to reflection. The teacher acted as a facilitator who provided direction through guiding questions, while students were more dominant in the exploration and investigation process. To provide a quantitative overview of student engagement, activity observation data were analyzed using a student activity observation sheet instrument. In addition, the quality of group presentations was assessed based on aspects of communication, content, and collaboration. The recapitulation of student activity observations and presentation assessments are shown in Table 1 and 2.

Table 1. Recapitulation of student activity observation data in PjBL-SA

Student Activity	Engagement Percentage	Category
Environmental observation	85%	High
Asking questions (questioning)	67%	Medium
Gathering field data	91%	Very High
Group discussion	88%	High
Designing prototype	79%	High
Presenting results	81%	High
Average	82%	High

Table 2. Group presentation assessment

Group	Communication (0–100)	Content (0–100)	Collaboration (0–100)	Total Score	Category
1	80	82	90	84	Good
2	76	80	85	80	Good
3	79	86	88	84	Good
4	78	81	87	82	Good
5	77	83	90	83	Good
Average	78	82	88	83	Good

Teacher and student responses to the implementation of PjBL-SA

Interview results with the teacher showed that the implementation of the Project-Based Scientific Approach (PjBL-SA) required more intensive preparation compared to conventional methods, especially in project planning and the development of learning tools. Nevertheless, the teacher considered this approach effective in helping students connect theory with practice through project-based activities related to their daily lives. This finding aligns with constructivist learning theory, which posits that knowledge is constructed through active engagement and contextual experiences rather than passive transmission (Vygotsky, 1978). The teacher also emphasized that PjBL-SA increased student motivation, creativity, and independence in learning. These observations are consistent with research showing that project-based learning enhances intrinsic motivation by providing autonomy, relevance, and challenge in learning tasks (Ayaz & Söylemez, 2015; Deci & Ryan, 2000).

The teacher perceived a change in the classroom atmosphere to one that was more active, collaborative, and student-centered. This transformation supports the findings of Rehman et al., (2024), who demonstrated that PjBL fosters a positive classroom climate by increasing student engagement, peer interaction, and responsibility. Furthermore, student-centered environments have been shown to improve social-emotional outcomes and promote deeper learning (Bell, 2010; Trilling & Fadel, 2009).

Meanwhile, the results of the questionnaire given to students (n = 28) confirmed these findings. The majority of students gave a positive response to the implementation of PjBL-SA: 78% reported being more motivated to learn, 82% found it easier to understand IPAS concepts through direct practice, and 75% enjoyed group learning. This supports findings from Liu and Pásztor (2022), who found a significant correlation between active learning engagement and conceptual understanding in science subjects. The data indicate that active student involvement in projects makes learning more meaningful and personally relevant, in line with the principles of meaningful learning proposed by Ausubel (1968), which emphasize the integration of new knowledge into existing cognitive structures through relevant experiences.

However, some challenges also emerged, where about 18% of students reported difficulty dividing group tasks evenly. This issue echoes findings from Gillies (2019), who noted that effective collaborative learning requires structured group management, equitable task distribution, and reflective dialogue. Thus, although PjBL-SA successfully promoted collaboration, a more deliberate strategy is needed to ensure balanced participation and accountability among group members.

Overall, both teacher and student responses indicate that the implementation of PjBL-SA had a positive impact on motivation, engagement, and understanding of IPAS concepts. This aligns with the results of recent meta-analyses showing that project-based learning significantly improves students' motivation and academic achievement, with a moderate to large effect size (Hedges' g = 0.58–0.72). Furthermore, the emphasis on autonomy, collaboration, and contextual application within PjBL-SA reflects the pedagogical orientation of the Merdeka Curriculum, which promotes authentic, reflective, and student-driven learning experiences (Kemendikbudristek, 2022). A summary of the student questionnaire results can be seen in Table 3.

Table 3. Summary of student responses to PjBL-SA implementation (n = 28)

Aspect of Student Response	%	Description
Felt more motivated to learn	78%	PjBL-SA increased learning enthusiasm because the activities were more meaningful.
Found it easier to understand IPAS concepts through practice	82%	Experiment and project activities helped connect theory with practice.
Enjoyed learning in groups	75%	Collaboration made learning more fun and interactive.
Experienced difficulty dividing tasks in the group	18%	Indicated a challenge in the management of cooperation among members.

Difference in student critical thinking ability through PjBL-SA implementation

The analysis of pretest and posttest critical thinking skills showed a significant increase after the implementation of the Project-Based Scientific Approach (PjBL-SA). In the initial stage (pretest), the average critical thinking score for students was 62.3, which was in the "sufficient" category. After the intervention, the average score increased to 78.9, placing it in the "good" category. The results of the paired t-test obtained a value of t=6.24

with a significance of $p<0.05$, which indicates a significant difference in students' critical thinking ability before and after the implementation of PjBL-SA. Thus, this model is proven effective in improving students' critical thinking skills.

When viewed based on critical thinking indicators adapted from Ennis, the largest increase occurred in the inference indicator (drawing conclusions) with a gain score of 0.42. This indicates that project activities, such as observing the environment and designing a prototype eco-friendly trash can, directly encouraged students to connect facts, organize data, and formulate logical conclusions. Meanwhile, other indicators such as clarification, evaluation, and decision-making also experienced an increase, although with a lower gain score. This finding strengthens the argument that PjBL-SA not only emphasizes the mastery of IPAS concepts cognitively but also trains higher-order thinking skills through a collaborative, investigative, and reflective process. Therefore, this approach is highly relevant for implementation in IPAS learning at the elementary school level. The details of the pretest and posttest average score differences are presented in Table 4 below.

Table 4. Comparison of pretest and posttest scores for student critical thinking skills

Critical Thinking Indicator	Average Pretest	Average Posttest	Gain Score	Improvement Category
Clarification	63.1	76.2	0.32	Medium
Inference	60.8	80.5	0.42	High
Evaluation (Evaluating arguments)	62.5	78.1	0.35	Medium
Decision-Making	62.9	80.0	0.37	Medium–High
Overall Average	62.3	78.9	0.36	Medium–High

Relationship between project-based learning process and the development of student critical thinking skills

To answer the fourth research question, a Pearson correlation analysis was conducted between the students' engagement scores in the PjBL-SA process (measured by a classroom activity rubric: discussion participation, observation involvement, contribution to product creation, and presentation) and their critical thinking test scores on the posttest. The analysis results showed a correlation coefficient of $r=0.63$ with $p<0.01$, which means there is a strong and significant positive relationship between student engagement in the project and the development of their critical thinking skills.

This finding shows that the higher the level of student participation in each stage of project-based learning, the greater the improvement in their critical thinking skills. The most prominent indicators were inference and evaluation, where students who actively discussed and presented ideas tended to have higher scores than less involved students. Thus, it can be interpreted that critical thinking skills do not develop instantly but grow through authentic, collaborative, and real-world problem-based learning experiences. The PjBL-SA model provides a space for students to integrate knowledge with practice, train their confidence in expressing opinions, and develop analytical skills through social interaction and contextual problem-solving activities.

Before presenting the correlation results, the students' engagement in the PjBL-SA process was first measured using a classroom activity rubric that included aspects of discussion, observation, product creation, and presentation. Then, these engagement scores were compared with the post-intervention critical thinking test results. The analysis was conducted with a Pearson correlation test to see the extent to which student involvement in the project was related to the improvement of critical thinking skills.

Table 5. Relationship of student involvement in projects with critical thinking skills

Variable	r	Sig.	Interpretation
Student involvement in the project (activity rubric) ↔ Critical thinking skills (posttest)	0.63	0.001	Strong positive relationship, significant at α=0.01

The results of this study show that the implementation of the Project-Based Scientific Approach (PjBL-SA) in 5th-grade IPAS learning at SDN 013 Tana Tidung has a positive impact on student engagement, teacher and student responses, and the improvement of critical thinking skills. The implementation of PjBL-SA took place through five stages: planning, project execution, teacher mentoring, presentation of results, and reflection. These stages align with the framework of the scientific approach (observing, questioning, experimenting, reasoning, communicating) integrated into project-based pedagogy.

In the planning stage, the teacher guided students to identify local environmental issues such as waste management and water pollution. This activity encouraged students to conduct observations and formulate questions as the basis for their project research. This is consistent with Bell (2010), opinion that real-world problem-based investigation can increase student engagement and inquiry skills. This finding is reinforced by the results of documentation such as student reflection journals, which showed high enthusiasm for designing real solutions to environmental problems. Student products, such as a recycling campaign poster and a simple water filter prototype, prove that they were able to connect IPAS concepts with practical solutions. According to Amini this process reflects the application of reasoning and communication skills, which are at the core of scientific learning.

The questionnaire results showed positive responses from both teachers and students. 78% of students felt more motivated, 82% found it easier to understand IPAS concepts through direct practice, and 75% enjoyed learning in groups. However, a small portion of students (18%) admitted to having difficulty dividing group tasks. This shows that PjBL-SA is capable of creating an active, collaborative, and student-centered learning atmosphere, as affirmed by Khoudri et al. (2023), that PjBL increases student participation and autonomy. In addition, teacher interviews revealed that this model requires more intensive preparation than conventional methods. However, the teacher found that PjBL-SA's flexibility made it easy to adapt learning to the local context and student characteristics, in line with hasanah findings on the flexibility of project-based learning to create an inclusive learning environment.

The results of the paired t-test showed a significant increase in students' critical thinking skills ($t=6.24$, $p<0.05$), with the average score increasing from 62.3 (sufficient category) to 78.9 (good category). The indicator that experienced the largest increase was inference (gain score 0.42), which means students became more skilled at drawing conclusions based on the data they collected. This result is in line with Ennis (1993), who states that critical thinking skills can develop through structured inquiry and data analysis exercises. In addition, the presentation and reflection sessions also provided opportunities for students to evaluate information, argue, and communicate results, as explained by Facione and Gittens, (2015) that these activities strengthen the analysis and evaluation aspects of critical thinking.

The Pearson correlation analysis showed a strong positive relationship ($r=0.63$, $p<0.01$) between student engagement in the project and critical thinking skills. This finding indicates that the more active students are in following project activities such as observation, experimentation, discussion, and presentation the higher their critical thinking skills. This aligns with Vygotsky (1978) theory of the zone of proximal development, which emphasizes the importance of collaboration and scaffolding in developing higher-order thinking skills. By working in groups and receiving guidance from the teacher, students can exceed their individual capabilities and build critical thinking skills through challenging learning experiences.

Theoretically, this research supports the constructivist view that knowledge is built through authentic experiences and social interaction (Trilling & Fadel, 2009; Vygotsky, 1978). PjBL-SA is proven to be able to integrate 21st-century skills such as critical thinking, collaboration, and creativity with the character values of the Pancasila Student Profile. Practically, the implementation of PjBL-SA in IPAS helps students connect theory with practice, build environmental awareness, and foster a sense of responsibility and independence. Nevertheless, challenges such as the division of roles in groups and time constraints need to be anticipated through a more systematic classroom management strategy, for example, by rotating roles and having a more flexible time allocation.

CONCLUSION

The implementation of the Project-Based Scientific Approach (PjBL-SA) in IPAS learning for Grade 5 students at SDN 013 Tana Tidung demonstrated that this model can effectively transform classroom learning into an active, collaborative, and student-centered environment. Through well-structured stages of planning, project execution, mentoring, presentation, and reflection, PjBL-SA enabled students to experience meaningful learning that connects theoretical understanding with real-world application. This approach provided students with opportunities to observe, investigate, and create tangible products related to environmental issues, which enhanced both their cognitive and practical competencies.

Teachers reported that while the approach required more intensive preparation particularly in designing project instruments and managing learning time it proved effective in promoting engagement and contextual understanding. Students' responses further confirmed the effectiveness of the model: 78% of students expressed higher motivation to learn, 82% found it easier to comprehend IPAS concepts through direct practice, and 75% enjoyed collaborative group work. Nevertheless, a small proportion of students still encountered challenges in task division and group coordination, highlighting the importance of structured collaboration strategies in project-based learning.

Quantitative analysis showed a significant improvement in students' critical thinking abilities, as reflected by an increase in average test scores from 62.3 (sufficient) in the pre-test to 78.9 (good) in the post-test ($t = 6.24$, $p < 0.05$). The most notable improvement occurred in the inference indicator, demonstrating that contextual, inquiry-oriented learning effectively develops students' ability to analyze and draw logical conclusions. The Pearson correlation result (r = 0.63, p < 0.01) also indicated a strong positive relationship between students' project engagement and the development of their critical thinking skills. These results align with findings from recent studies emphasizing that PjBL encourages higher-order thinking through authentic and collaborative problem-solving contexts.

In essence, the implementation of PjBL-SA not only improved students' academic performance but also fostered essential 21st-century competencies such as critical thinking, creativity, collaboration, and communication. It also nurtured environmental awareness and responsibility, reflecting the holistic goals of the *Merdeka Curriculum* that emphasize contextual, inquiry-based, and value-driven education. Therefore, PjBL-SA can be considered an innovative and effective pedagogical model for enhancing the quality of IPAS learning in elementary education, particularly in promoting meaningful, integrated, and future-oriented learning experiences.

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