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Abun Indigenous Knowledge in Conservation Project Based Learning and Student Problem Solving and Collaboration Across Six Schools in Southwest Papua

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Abstract

Indigenous and place-based knowledge can give project-based learning (PjBL) locally meaningful content. This study reports curriculum development and a comparison of problem-solving and collaboration performance across six non-randomly allocated junior secondary schools in Tambrauw Regency, Southwest Papua, Indonesia. An Abun conservation-oriented PjBL curriculum was developed through needs assessment, consultation with community knowledge holders, expert appraisal, and classroom piloting. The outcome summaries covered 150 Grade VII students: 50 each in Abun conservation-oriented PjBL, school-developed PjBL, and conventional instruction, with two schools in each condition. Mean problem-solving scores were 78.02, 68.82, and 59.70, respectively; corresponding collaboration scores were 74.28, 63.48, and 50.32. The original student-level ANOVAs reported $F(2, 147) = 153.149$ for problem-solving and $F(2, 147) = 311.862$ for collaboration (both nominal $p < .001$). However, these tests did not account for school clustering, and available summaries could not establish baseline equivalence or assessor reliability. Expert appraisal scores were 100%, 91.58%, and 97.14% for the curriculum, modules, and media; these measure product appraisal, not student gains. The observed score pattern favors the integrated curriculum condition but cannot isolate an independent causal effect of Indigenous content. The principal contribution is an explicitly mapped connection between Abun cultural and conservation knowledge, planned inquiry tasks, and assessed competencies.

1. Introduction

Problem-solving and collaboration have become central priorities in educational systems seeking to prepare young people for complex social, technological, and environmental challenges. These competencies require students to do more than reproduce information: they must recognize a problem, weigh evidence, coordinate perspectives, propose alternatives, and act responsibly with others. An interdisciplinary account of learning and development emphasizes the interaction between cognition, relationships, experience, and supportive learning environments [1]. Nevertheless, translating competence-oriented policy into classroom practice remains difficult. In a three-year professional-development program comprising 56 courses and 1,187 teachers, Haug and Mork [2] identified the importance of modeled strategies and practical teaching resources. A survey of 8,265 students in 100 Swiss schools likewise illustrates the complexity of establishing evidence for broadly defined twenty-first-century skills rather than assuming their development from technological access alone [3]. These perspectives suggest that learning environments must deliberately structure opportunities to think, communicate, and collaborate.

Project-based learning (PjBL) provides one approach for creating these opportunities by organizing instruction around sustained inquiry, student decisions, group work, and the construction of meaningful products [4]. The intended benefits encompass different outcomes, however, and the distinctions among them are important. Reviewing 76 publications, Guo et al. [5] classified PjBL outcomes as cognitive, affective, behavioral, and artifact-related, with considerable diversity in the instruments used. A meta-analysis of 31 experimental and quasi-experimental studies examined computational-thinking

dimensions that included problem-solving and collaboration [6]. Related syntheses reported a heterogeneous motivational benefit of problem-driven instruction [7] and a positive but context-dependent mean effect of informal STEM projects across 26 studies involving 3,202 students [8]. Although these findings justify interest in PjBL, the magnitude and mechanisms of any educational benefit cannot be transferred uncritically across student ages, subjects, and instructional settings.

An important challenge is that projects are not invariably meaningful to the learners undertaking them. Place-based and culturally contextualized education offers a way to make disciplinary questions recognizable within students' everyday environments. Comparative evidence from project-based social studies and literacy teaching in relatively disadvantaged elementary settings indicates that contextual interventions can be evaluated in authentic schools, even though such findings are not direct evidence for the present population [9]. A recent systematic review of 68 place-based science studies identified community projects, biodiversity, local knowledge, and human–environment relationships as recurring emphases, alongside constraints relating to resources and teacher capacity [10]. Area-based curriculum research similarly emphasizes local participation while also questioning unequal access to valued knowledge [11]. As Thomas [12] argues in relation to curriculum policy, local relevance should complement, not replace, rigorous educational expectations. The pedagogical problem is therefore how local knowledge can be transformed into structured inquiry rather than added as contextual decoration.

In Tambrauw Regency, Southwest Papua, these questions arise in an environment where customary territorial knowledge and marine and terrestrial conservation are locally salient. A district education-quality report consulted during the curriculum needs assessment (2022) recorded instructional-quality and cognitive-support indices of 1.77 and 1.66, respectively. These contextual indicators describe the conditions motivating curriculum development, not changes attributable to the intervention; the original district report and indicator definitions should be supplied for independent verification. School interviews undertaken during the needs assessment suggested uneven access to structured local-content materials and frequent reliance on teacher-led explanation. The design challenge was how to translate community-derived knowledge into assessable inquiry, project products, and cooperative classroom activity rather than treating local culture as illustrative background.

The integration of Indigenous knowledge into formal learning requires more than the selection of culturally recognizable topics. It requires attention to the ownership, interpretation, and educational appropriateness of community knowledge. A systematic review involving 156 sources emphasizes the importance of equitable relationships between Indigenous and scientific knowledge systems and the protection of community intellectual interests [13]. Molnár et al. [14] similarly recommend more reciprocal partnerships between ecological science and ethnoecological knowledge. Within Indonesia, Noviana et al. [15] demonstrated how specific local expressions, advice, and prohibitions could be identified and interpreted within conservation and disaster-related education; these findings do not imply that the same practices occur among Abun people. Other Indonesian studies have examined local values in early-childhood character education [16] and contextual curricula in relation to digital-literacy

development [17]. Together, these examples underline the need to document particular practices before claiming that they have been authentically integrated into learning.

For the Abun setting, the locally developed instructional materials brought together customary territories, geographical boundaries, cultural expressions, marine and terrestrial conservation, and environmental challenges. Such themes may create opportunities for reasoning about competing priorities, shared resources, and possible solutions. Howard [18] advocates educational purposes that extend beyond isolated knowledge acquisition toward meaningful engagement with social and ecological problems. A systematic review of socioscientific-issue teaching also points to the value of examining real-world problems through evidence and competing perspectives [19]. Importantly, a culturally meaningful theme does not automatically constitute a high-quality project. Farrow et al. [20] distinguish between project-oriented curriculum designs and their actual classroom enactment, while research on project-based and electronic project-based instruction shows the need to specify learning processes rather than infer outcomes from labels [21]. Hence, the instructional intervention needs to be described through the tasks students performed, the products they produced, and the competencies assessed.

Current PjBL scholarship continues to highlight the potential for developing twenty-first-century capacities while documenting variation in study designs and implementation quality. A recent systematic review of K–12 PjBL selected 20 empirical studies for focused narrative synthesis after a larger bibliometric search, underscoring that findings must be interpreted within clearly described instructional conditions [22]. A short place-based STEM program involving 24 middle-school students further illustrates the relevance of learning connected to local environments, although outreach experiences differ from classroom curriculum implementation [23]. These studies collectively leave a narrower empirical question insufficiently addressed: whether culturally contextualized PjBL is associated with different problem-solving and collaboration performances when compared not only with conventional teaching but also with a school-developed curriculum already employing PjBL. The second comparison is particularly important because it reduces the temptation to attribute every observed difference to project-based pedagogy alone.

The study addresses this question through an Abun Culture-Based Conservation Curriculum and a comparison of three school-level instructional conditions among Grade VII students: Abun conservation-oriented PjBL, school-developed local-content PjBL, and school-developed conventional instruction. The outcomes are rubric-assessed problem-solving and collaboration rather than academic achievement, cultural identity, or cultural knowledge retention. A distinguishing design feature is the presence of a second, non-Abun PjBL comparison group; however, differences in curricular materials, schools, teachers, and baseline conditions prevent the comparison from isolating a cultural-content effect. The paper therefore has two contributions: a documented mapping from Abun knowledge to the planned PjBL tasks and assessment dimensions, and a cautiously interpreted description of competency-score differences in real schools.

1.1 Problem-Solving and Collaboration as Learning Competencies

Problem-solving refers to a sequence of interdependent cognitive actions through which learners recognize a situation, identify relevant information, evaluate alternative courses of action, and justify an implemented solution. It cannot be assessed adequately by the quality of a final artifact alone, because students may produce an acceptable product while displaying limited evidence of reasoning. Greenstein [24] proposes authentic assessment approaches for complex competencies, including problem-solving, and emphasizes observable performance. Research on contemporary assessment likewise suggests that the emphasis on twenty-first-century capacities requires forms of evidence beyond routine knowledge tests [25]. In the Abun investigation, the operational indicators comprise defining problems, analyzing their features, formulating solutions, evaluating alternatives, and implementing responses. These processes are particularly relevant where project questions concern actual conservation and community issues rather than closed exercises.

Collaboration concerns the quality of coordinated participation, not simply the presence of students in a group. It involves productive contributions, respect for different views, negotiated compromise, and responsibility for shared objectives. Gillies [26] shows why productive classroom dialogue depends on task design and teacher scaffolding that allow students to explain and question their reasoning. More recent assessment work has sought to distinguish each student's contribution from the final group outcome: Song et al. [27] examined peer judgments and individual contributions, whereas Ying and Tiemann [28] developed task-related criteria for assessing collaborative problem-solving. These perspectives justify the use of behavioral rubrics in the present study while also emphasizing the need to verify scoring consistency across teachers, projects, and schools.

1.2 Local Wisdom and Culturally Contextualized Education

Culturally contextualized education treats nearby people, places, languages, and practices as resources for constructing disciplinary understanding. An area-based curriculum can therefore provide students with greater access to information and problems embedded in their communities, while requiring intentional alignment with learning goals [11, 12]. Place-based pedagogy also offers alternatives to the separation of classroom content from experience. For example, Wason-Ellam [29] examined how literary learning could be connected to embodied experience of place. The theoretical contribution of locality is not geographic proximity by itself; it is the opportunity to situate investigation within meaningful relationships and contexts. Student engagement remains a multidimensional, context-dependent process rather than a guaranteed result of local relevance [30].

For Indigenous knowledge, educational translation requires consultation with legitimate knowledge holders and sensitivity to what may or may not be appropriate for teaching. Indonesian studies offer useful conceptual parallels but are not evidence about Abun practices specifically: Noviana et al. [15] documented culturally transmitted environmental guidance in Riau, while Sakti et al. [16] examined the

role of local values and educational relationships in Yogyakarta. A systematic review of 12 studies addressing 11 early-childhood programs for Indigenous children also stressed culturally responsive design and research practices [31]. These sources indicate why the Abun study's interviews, documentation, and community discussions should be considered part of intervention construction, rather than merely contextual background.

1.3 Project-Based Learning and Authentic Learning Activities

Project-based learning organizes the teaching sequence around a problem that motivates investigation and requires students to develop an accountable outcome. In a genuine project, students formulate questions, gather information, evaluate alternative strategies, distribute tasks, and communicate the reasoning behind a completed product. Bell [4] and Almulla [32] connect this instructional format with learner agency and participation. The resulting products may take material, audiovisual, representational, or performative forms. An interdisciplinary STEAM project involving a designed paper-cutting lamp illustrates how a tangible artifact can require conceptual understanding alongside practical production [33]. Similarly, Chen et al. [34] examined creative thinking within project-oriented learning. These outcome domains should nevertheless remain distinct from the problem-solving and collaboration rubrics used in Tambrauw.

Successful enactment depends on how teachers structure inquiry and group interaction. Chang and Lee [35] investigated a team-teaching model for coordinating project instruction across subject areas. A review of STEM-oriented PjBL applications highlights its potential for connecting investigations and disciplinary learning [36], whereas Musa et al. [37] explored applied PjBL in language and workplace-related learning. Technology-enhanced collaborative inquiry is another possible support, but Chen and Chen [38] indicate that successful group inquiry requires purposeful communication and shared evidence rather than technology alone. Accordingly, the Abun intervention is most appropriately understood through its specific driving questions, local knowledge resources, project products, and modes of cooperation, rather than through an undifferentiated claim that PjBL is effective.

1.4 Abun Indigenous Knowledge and Environmental Conservation

The Abun context includes customary-territory knowledge, community history, artistic expression, craft-making, food practices, and relationships to marine and terrestrial environments. In the curriculum-development records, customary boundaries, coastal conservation, terrestrial and river protection, and cultural performances were selected as sources for instructional questions. The planning documents also specified noken craftwork, koba-koba products, traditional dress, and food preparation. Their presence in a curriculum design establishes the cultural content of the intervention, but does not demonstrate that every project was completed in each school. Integrating these topics responsibly requires engagement with appropriate knowledge holders, as stressed in research on Indigenous knowledge partnerships [13, 14].

Context-rich project work may also develop a bridge between reasoning and interpersonal coordination. A study involving 57 ninth-grade students connected online simulation-based collaborative problem-solving with communication and solution testing [39]. Motivation research further identifies personal and collaborative orientations as potential influences on group problem-solving performance [40]. These results do not establish the effects of Abun knowledge itself, but they identify plausible mechanisms: students must exchange evidence, negotiate actions, and revise proposals during a shared inquiry. In a conservation-oriented project, the quality of these processes depends on accessible cultural material and sustained facilitation as much as on the environmental topic selected.

1.5 Conceptual Framework and Research Hypotheses

The conceptual framework distinguishes three components: (i) Abun knowledge and environmental-conservation themes provide locally meaningful situations and sources; (ii) PjBL provides structured inquiry, allocation of group roles, creation of products, presentation, and reflection; and (iii) rubrics describe observed problem-solving and collaboration performance. The proposed instructional mechanism is that familiar problems may support recognition and evidence-based discussion, while shared products may create occasions for planning and negotiation. That mechanism is a theoretical explanation, not a separately measured mediator. The comparison with school-developed PjBL narrows the pedagogical contrast but cannot hold teacher practices, digital supports, or school conditions constant.

The study's overarching hypothesis is that curriculum-integrated Abun conservation PjBL is associated with higher competency scores than the two alternatives. Four operational predictions follow: the Abun group will show higher problem-solving than the conventional group (H1); higher problem-solving than ordinary PjBL (H2); higher collaboration than the conventional group (H3); and higher collaboration than ordinary PjBL (H4). Comparisons of ordinary PjBL with conventional instruction further clarify the pattern of between-group differences. These predictions concern observed performance in the original school-based evaluation, not general academic achievement, long-term retention, or change in cultural identity. Teacher support and the enactment of projects remain important interpretive conditions, as emphasized by Haug and Mork [2] and Farrow et al. [20].

2. Materials and Methods

2.1 Research Design and Development Approach

The study employed a quasi-experimental design involving three non-equivalent instructional conditions implemented across six junior secondary schools. Instructional conditions were determined at the school level without individual random assignment. Consequently, potential school-level confounding and within-school dependence were considered when interpreting the observed differences in student performance.

2.2 Research Setting, Participants, and Data Sources

The study was conducted in Grade VII local-content classes across six junior secondary schools in Tambrauw Regency, Southwest Papua, Indonesia. A total of 150 students participated in three instructional conditions, with 50 students from two schools in each condition. Participants were 150 Grade VII students aged 10–14 years. Because all participants were minors, parental or legal guardian consent procedures were implemented together with age-appropriate student assent. The Conservation-PjBL group comprised SMPN Bansu and SMPN Kwoor; the Conventional-PjBL group included SMPN Advent and SMPN Sausapor; and the Conventional group consisted of SMPN Bamusbama and SMP Imanuel Werur. Each participating class was planned to include approximately 25 students. Because the instructional conditions were organized at the school level, students within the same school could share contextual and instructional characteristics. School-specific outcome statistics and evidence of baseline equivalence were not available in the reported summary data.

2.3 Development of the Abun Local Wisdom-Contextualized PjBL Intervention

The Abun conservation-oriented instructional package comprised a curriculum document, learning modules, assessment rubrics, an online interaction platform, and 14 video resources linked from the modules. Content addressed Tambrauw geography, customary territories, Abun history and cultural expression, marine and river environments, and terrestrial conservation. The curriculum planned inquiry tasks around mapping, investigating environmental problems, developing proposals, collaborative presentations, and cultural documentation. Curriculum appendices further specify planned noken-making, koba-koba craftwork, traditional attire displays, and preparation of local food, accompanied in some cases by student-created video documentation. These examples describe the intended learning design; their completion by all evaluation students is not verified. This distinction accords with the need to distinguish planned from enacted project features [20, 42].

Table 1 traces the curricular linkage between local cultural or environmental material, the planned investigation or collaboration, and the anticipated project evidence. For example, conservation-zone mapping required identifying and explaining territorial information; coastal or river investigations required proposing responses; and cultural craft and food-production plans required group coordination and documentation. Curriculum schedules thus describe testable learning opportunities but do not on their own establish treatment fidelity or the presence of completed artifacts in all six schools.

Table 1
Curriculum-specified mapping of Abun/Tambrauw contexts to planned project activities and assessed competencies;

Curricular cultural / environmental context	Curriculum-specified inquiry or group activity	Anticipated product and assessment link (planned)
Tambrauw boundaries and conservation zones	Investigate jurisdictional boundaries, map environmental protection areas, compare evidence	Geographical map and group explanation; problem definition and evidence-based reasoning
Abun history and customary territory	Interpret community history and discuss boundaries of customary land using permitted sources	Territorial map or visual representation; collaborative analysis
Abun songs and dances	Interpret cultural expression and plan collaborative performances or documentation	Group performance or video plan; division of roles, communication
Leatherback turtle habitat and coastal pollution	Identify threats, consider local causes and potential responses	Conservation poster or awareness video; problem-solving and group decisions
Terrestrial and river environments	Discuss environmental damage and propose realistic responses	Group proposal/presentation; solution development and appraisal
Noken-making cultural materials	View craft documentation; curriculum plan also proposes making noken	Planned craft and/or video documentation; cooperation and planning
Koba-koba / pandan-based craft	Plan group production of woven pandan goods and documentation of making process	Planned koba-koba object or craft video; productive work and responsibility
Traditional attire and cultural display	Study dress using designated cultural resources; organise group display or documentation	Planned cultural presentation; respectful collaboration and communication
Traditional food preparation	Plan group preparation and documented explanation of local food practices	Planned preparation/tutorial video; group roles and communication

The planned examples in Table 1 also document how cultural resources were operationalized in curricular design. Specifically, activities involving crafted goods, cooking, and cultural dress were proposed in the curriculum schedule, whereas the outcome summaries do not contain an item-by-item record of their completion by school. Problem-solving and collaboration are therefore assessed at the curriculum-condition level, not as separate outcomes attributed to individual cultural activities.

2.4 Research Instruments and Measurement

Problem-solving was assessed against five analytic dimensions: defining a problem, analysing its causes or characteristics, formulating solutions, evaluating alternatives, and implementing a response.

Collaboration was assessed against four dimensions: productive work, respect for others, compromise, and responsibility. The appended performance rubrics specify five ordered levels (1 = very poor; 5 = very good), with descriptors tailored to Grade VII learners, adapted from Greenstein [24]. Problem-solving assessment used curriculum-linked case scenarios and evaluated students' proposed or implemented responses. Collaboration assessment drew on group activities; the procedural account describes peer judgments being forwarded to teachers for collation. The same collaboration rubric was specified for the comparison conditions, although the summary evidence does not document full scoring standardisation, whether assessors were blind to condition, how rubric ratings were converted into the reported outcome scale, or inter-rater agreement. Consequently, instrument structure is documented, but equivalent measurement quality across schools cannot be assumed.

The curriculum document, modules, media, and language were appraised through specialist review using component-specific checklists and a percentage of obtained scores relative to maximum possible scores. Such percentages indicate expert judgments of product suitability, not psychometric validity of the pupil-level tests or proof of learning improvement. Student and teacher questionnaires in the 25-student, two-meeting pilot separately assessed perceived practicality and implementation. The summary data do not establish rater-training procedures, cross-school score calibration, or inter-rater reliability; these should be reported only if corresponding research records can be produced. Prior collaboration-assessment literature motivates these measurement concerns but is not evidence of reliability in this study [27, 28].

2.5 Effectiveness Testing and Statistical Analysis

The original one-way ANOVA and LSD post hoc comparisons were conducted using individual student scores. However, because instructional conditions were implemented at the school level, the analyses did not account for potential within-school correlations. Consequently, the reported p-values and confidence intervals represent nominal student-level inference rather than school-cluster-adjusted estimates. Given the limited number of participating schools and the absence of school-specific individual-level data for reanalysis, the findings are primarily interpreted as descriptive between-group differences rather than definitive evidence of causal effects.

3. Results

3.1 Curriculum Products and Expert Validation

Curriculum development generated the Abun Culture-Based Conservation Curriculum, learning modules, assessment guidance, videos, and an online interaction platform. The curriculum linked local geographic and customary-territorial knowledge with cultural expression and marine, river, and terrestrial conservation questions. Fourteen short videos accessible through module links or scan codes were designed as learning resources, not as evidence of completed student products. These curriculum-to-activity relationships are shown in Table 1. The distinction between curriculum design and enactment is important in project-based education [20].

The reported appraisal percentages were 100% for the curriculum document, 91.58% for the learning module, 97.14% for audiovisual media, and 71.11% for language/readability (Table 2). The underlying appraisal procedure expressed obtained checklist scores as a share of maximum possible scores; categories in Table 2 reflect the study's stated rating criteria. These are judgments of product acceptability within a particular expert-review procedure, not measures of measurement reliability, classroom fidelity, or treatment effects. The lower language score identifies a concrete need for terminology and clarity revisions. Information about evaluator composition and rating criteria should accompany any fully reproducible report of this development phase.

Table 2
Aggregate expert validation scores for the instructional package.

Component	Reported score	Source classification
Curriculum document	100.00%	Very valid
Learning module	91.58%	Very valid
Instructional media	97.14%	Very valid
Language/readability	71.11%	Valid; revision advised

Revisions documented in the source concerned the consistent use of cultural terminology, treatment of sensitive expressions, video labeling, source acknowledgment, and strengthening affective objectives within the curriculum document. One specific correction replaced an imprecise term for language variation with the intended description of accent. Another revision clarified the caption accompanying a noken-making video. The media specialist also proposed clearer source links and mapping information. The development team incorporated some suggestions while noting that the geographical extent of Abun customary lands complicated comprehensive location tagging. These changes demonstrate that cultural and pedagogical accuracy required editorial negotiation during development, even where experts assigned high quantitative validation scores.

3.2 Classroom Activities and Implementation Responses

Curriculum and teaching narratives connect geographic and customary territory questions, art and cultural expression, and local conservation problems to inquiry, maps, awareness products, and group presentations. The appendices additionally specify planned cultural tasks involving noken, woven pandan products (koba-koba), local food preparation, and traditional dress. The evidence does not establish that all planned cultural tasks were completed by each class or that every school experienced identical teachers, projects, or amounts of instruction. Accordingly, Table 1 describes the curriculum's educational mapping, not an observed six-school fidelity record.

The limited pilot involved 25 Grade VII learners at SMPN Bansu over two meetings. Student questionnaire scores were 95% for opening activities, 93% for main activities, and 90% for closing activities; teacher assessment percentages were 90% for curriculum completeness, 88% for module

guidance, 86% for implementation difficulty, 80% for time allocation, and 86% for perceived student response (Table 3). These percentages describe responses on appraisal instruments, not proportions of pupils whose skills improved. They pertain only to the limited pilot and must not be generalized as a representative implementation survey of the entire six-school evaluation.

Table 3
Pilot implementation responses from students and teacher.

Respondent	Evaluated aspect	Response
Students (n = 25)	Introduction to lesson	95%
Students (n = 25)	Core learning activities	93%
Students (n = 25)	Closing activities	90%
Teacher	Curriculum-document completeness	90%
Teacher	Clarity of module instructions	88%
Teacher	Implementation difficulty	86%
Teacher	Time allocation	80%
Teacher	Student response	86%

The field feedback showed that students appreciated the variety of learning activities and the opportunity to learn through familiar experiences rather than classroom explanation alone. Teachers reported that a curriculum document, integrated module, and linked videos assisted the presentation of local material that schools had previously struggled to organize. The evaluation also recorded substantial challenges. Limited time made dense content demanding, some students needed support in reading texts, internet connectivity restricted access to media, and inconsistent student attendance complicated group composition. Community participation, prior familiarity with local settings, and positive student attitudes were reported as supports. These comments are important for interpreting the findings: the instructional design was experienced within conditions that both enabled and constrained the intended project activities.

3.3 Problem-Solving Performance Across Instructional Conditions

Table 4 reports the problem-solving outcomes for 150 students in three groups of equal size. The Conservation-PjBL group had the highest mean, 78.02 (SD = 4.62685; 95% CI [76.7051, 79.3349]), followed by Conventional-PjBL, 68.82 (SD = 5.31724; 95% CI [67.3089, 70.3311]), and Conventional instruction, 59.70 (SD = 5.70088; 95% CI [58.0798, 61.3202]). Observed score ranges were 68–88, 62–99, and 44–79, respectively. The total mean was 68.8467 (SD = 9.12901). These descriptive results display a graded pattern: students receiving the culturally contextualized project curriculum achieved the highest

scores, ordinary project-based learning occupied an intermediate position, and the conventionally taught group had the lowest mean.

Table 4
Individual-level descriptive performance outcomes by school-assigned instructional condition (n = 50 pupils per condition).

Outcome	Instructional group	Mean	SD	95% CI	Range
Problem-solving	Conservation-PjBL	78.02	4.62685	76.71–79.33	68–88
Problem-solving	Conventional-PjBL	68.82	5.31724	67.31–70.33	62–99
Problem-solving	Conventional	59.70	5.70088	58.08–61.32	44–79
Collaboration	Conservation-PjBL	74.28	4.39870	73.03–75.53	67–83
Collaboration	Conventional-PjBL	63.48	2.08238	62.89–64.07	60–67
Collaboration	Conventional	50.32	6.75048	48.40–52.24	34–60

The original student-level ANOVA for problem-solving yielded $F(2, 147) = 153.149$ with nominal $p < .001$ (Table 5), based on between-group and within-group sums of squares of 8,390.613 and 4,026.860. The LSD table reported descriptive mean gaps of 18.32 (Conservation-PjBL versus Conventional; nominal 95% CI 16.2513–20.3887), 9.20 (Conservation-PjBL versus Conventional-PjBL; 7.1313–11.2687), and 9.12 (Conventional-PjBL versus Conventional; 7.0513–11.1887), each with nominal $p < .001$ (Table 6). The confidence intervals assume independent student scores and do not reflect school-level condition assignment. Therefore, the 9.20-point difference between the two PjBL groups is informative descriptively but should not be interpreted as an isolated causal effect of Abun cultural content.

Table 5
Original pupil-level one-way analyses of variance; F and nominal p values are unadjusted for school clustering.

Outcome	Between SS (df = 2)	Within SS (df = 147)	MS error	F	p
Problem-solving	8,390.613	4,026.860	27.394	153.149	< .001
Collaboration	14,398.453	3,393.440	23.085	311.862	< .001

Table 6
Original pupil-level LSD pairwise differences and nominal 95% confidence intervals; uncertainty estimates are unadjusted for school clustering.

Outcome	Comparison	Mean diff.	95% CI	Reported p
Problem-solving	Conservation-PjBL – Conventional	18.32	16.2513–20.3887	< .001
Problem-solving	Conservation-PjBL – Conventional-PjBL	9.20	7.1313–11.2687	< .001
Problem-solving	Conventional-PjBL – Conventional	9.12	7.0513–11.1887	< .001
Collaboration	Conservation-PjBL – Conventional	23.96	22.0610–25.8590	< .001
Collaboration	Conservation-PjBL – Conventional-PjBL	10.80	8.9010–12.6990	< .001
Collaboration	Conventional-PjBL – Conventional	13.16	11.2610–15.0590	< .001

Table 6 note: all nominal intervals were checked against the detailed SPSS comparison output; their precision must not be interpreted as a valid school-cluster-adjusted inference.

The preliminary pilot had also reported comparatively high scores for its five problem-solving indicators: defining a problem, 86.4; analyzing, 86.6; formulating solutions, 85.8; evaluating solutions, 86.2; and implementing solutions, 86.2. These pilot indicators should not be pooled with the wider effectiveness results because they describe a different evaluation stage. Furthermore, although the original plan specified pretest and posttest measures, the tables supporting the present effectiveness contrasts do not establish the magnitude of paired gains within individual students. The Conservation-PjBL condition exhibited the highest observed mean problem-solving score (78.02), followed by Conventional-PjBL (68.82) and Conventional instruction (59.70). These descriptive differences should not be interpreted as evidence of a causal intervention effect.

3.4 Collaboration Performance Across Instructional Conditions

Collaboration scores followed the same ordinal pattern as problem-solving. The Conservation-PjBL group achieved a mean of 74.28 (SD = 4.39870; 95% CI [73.0299, 75.5301]); Conventional-PjBL achieved 63.48 (SD = 2.08238; 95% CI [62.8882, 64.0718]); and Conventional instruction achieved 50.32 (SD = 6.75048; 95% CI [48.4015, 52.2385]). Score ranges were 67–83, 60–67, and 34–60, respectively. The pooled sample mean was 62.6933 (SD = 10.92743). Taken together with the problem-solving findings, these results suggest that the Conservation-PjBL condition had an advantage in both the reasoning-related and interpersonal competencies explicitly measured by the investigation.

The original collaboration ANOVA reported F(2, 147) = 311.862 with nominal p < .001 (Table 5); between-group and within-group sums of squares were 14,398.453 and 3,393.440, respectively. The LSD comparisons reported descriptive gaps of 23.96 points (Conservation-PjBL versus Conventional; nominal 95% CI 22.0610–25.8590), 10.80 (Conservation-PjBL versus Conventional-PjBL; 8.9010–12.6990), and 13.16 (Conventional-PjBL versus Conventional; 11.2610–15.0590), with nominal p < .001 (Table 6). These corrected intervals match the detailed SPSS output; they are not school-cluster-adjusted, and their nominal p values cannot support causal attribution to the curriculum package.

The limited pilot included additional collaboration indicators with means of 87.2 for productive work, 85.0 for respect, 72.2 for compromise, and 66.6 for responsibility. The pattern is informative because dimensions associated with constructive contributions and courtesy were higher than those associated with negotiation and accountable follow-through. Nevertheless, the pilot descriptive scores are not equivalent to the three-group outcome scores and cannot establish which particular collaboration behavior produced the difference between schools. Contemporary assessment research emphasizes the difficulty of attributing group outcomes to individual contributions, a distinction that remains relevant to interpretation of these rubrics [27, 28].

3.5 Distributional Checks and Reporting Boundaries

For all listed groups, Shapiro–Wilk p values exceeded .05, but the Kolmogorov–Smirnov analysis indicated deviations from normality in the Conservation-PjBL (.031) and Conventional-PjBL (< .001) problem-solving distributions. For Conventional-PjBL, the recorded maximum of 99 and marked positive skewness (3.813) warrant case-level review. This inconsistency does not justify inventing a corrected score or deleting an outlier. The original results are retained until the underlying records can be independently checked.

The mean-based Levene tests did not detect clear variance heterogeneity under the original .05 threshold (p = .068 for problem-solving and p = .549 for collaboration), but variance homogeneity does not establish independent observations. Because only two schools contributed to each instructional condition and the source provided no school-specific raw score files, neither baseline-adjusted analyses nor valid cluster-adjusted significance tests can be reconstructed. The group means and standard deviations are therefore emphasized as descriptive findings. A separate dissertation summary also reports outcome averages that do not match the detailed SPSS tables; the analyses here follow the full SPSS output, pending verification by the authors against original student records.

4. Discussion

4.1 Indigenous Knowledge as the Context of Project-Based Instruction

The curriculum demonstrates a design pathway for translating locally grounded sources into tasks that make disciplinary inquiry relevant to community concerns. Customary boundaries can motivate map-

based interpretation; marine conservation and river degradation can anchor cause-and-solution reasoning; and dress, craft, food, or performance documentation can support collaborative planning and communication. These are pedagogically specified possibilities evidenced by curriculum plans, not a claim that every practice was enacted or that each practice independently improved skill scores. In line with place-based reviews [10], the meaningful unit of contribution is the explicit cultural-source-to-inquiry-to-assessment linkage. Respectful authorization remains essential: concepts derived from Indigenous knowledge require accountable interpretation and governance rather than being freely reused because they appear educationally relevant [13, 14].

The study's cultural contribution is therefore methodological as well as contextual: rather than listing Indigenous practices as decorative examples, the curriculum specifies an educational pathway from local knowledge sources to a driving question, a shared inquiry product, and observable scoring dimensions. This is a design-level contribution; direct verification of student products, knowledge-holder authorization, and the enactment of each mapped activity remain important for subsequent research.

There is no justification for treating the practices of one Indigenous group as interchangeable with those of other communities. For example, Noviana et al. [15] document distinctive Riau environmental teachings, while Hadlos et al. [43], in a review of 325 studies, identify both the value of local and Indigenous knowledge for disaster risk reduction and tensions in how external institutions use that knowledge. The Abun curriculum is appropriately distinguished by its own documented interviews, focus-group discussions, and cultural appraisal, even as the available manuscript cannot establish that community consultation amounted to comprehensive approval of every knowledge representation. Future implementation should clarify cultural authority, consent, and access arrangements for interviews, videos, customary maps, and potentially sensitive environmental information.

4.2 Interpreting the Problem-Solving Difference

The problem-solving scores followed the ordering Conservation-PjBL > Conventional-PjBL > Conventional; the first condition exceeded ordinary PjBL by 9.20 observed score points. This is an interesting contrast between two project-oriented curricula, but differences in schools, resource packages, instructional delivery, and initial student performance were not controlled. It is therefore not possible to identify whether local knowledge, conservation content, teacher support, curricular quality, or their combination explains the observed gap. The evidence supports a school-based association with the integrated Abun curriculum condition rather than a unique cultural-content effect.

One plausible mechanism is that environmental and customary-territory problems make case interpretation accessible, after which learners can identify causes, compare solutions, and communicate an argued response. This interpretation is compatible with studies of socioscientific reasoning [19] and purposeful PjBL design [44], but the study did not measure cognitive mediation, process tracing, or moment-to-moment evidence exchange. Claims about a particular mental process must remain theoretical until direct classroom observations or artifact revision histories support them.

4.3 Collaboration as an Interpersonal Learning Outcome

Collaboration scores also favored Conservation-PjBL descriptively, with a 10.80-point gap relative to Conventional-PjBL and a 23.96-point gap relative to Conventional instruction. Planned group products could create opportunities for students to distribute tasks, exchange evidence, and negotiate responsibilities. However, these processes were not measured independently from the overall collaboration rubric, and higher scores could also reflect differences in school norms or assessor practice. Research on academically productive dialogue explains why communication quality and cooperative participation matter [26]; it does not demonstrate that the same mechanism produced the observed between-school difference. The pilot's lower compromise and responsibility indicators further show that collaboration should not be treated as a single undifferentiated behavior.

Research on peer contribution and collaborative problem-solving assessment [27, 28] illustrates the need to define the unit of scoring and ensure consistent interpretation of behavioral anchors. Because the school-specific reliability of the study's scoring was not documented, observed group gaps could be influenced by peer marking, teacher collation, group composition, attendance, or different project tasks. The current evidence cannot quantify these contributions; future studies should retain individual, group, and assessor identifiers so measurement quality can be evaluated before interpreting changes in collaborative competence.

Although the observed performance pattern favored Conservation-PjBL, the design does not distinguish the contribution of Indigenous cultural content from school characteristics, teacher practices, or differences in instructional resources. The results are therefore consistent with, but do not establish, the proposed educational benefits of the integrated curriculum.

4.4 Practical Implications for Resource-Constrained Schools

Expert ratings and pilot responses indicate that reviewers and early users generally regarded the curricular package as suitable and usable. These judgments must be distinguished from effectiveness evidence across the six evaluation schools. The comparatively low teacher rating for time allocation and field reports of variable literacy, unreliable internet, and student attendance demonstrate practical barriers to consistent enactment. The contrast between planned project features and classroom conditions accords with accounts of project-curriculum enactment and teacher preparation [20, 2, 42], but does not establish the same mechanisms in all sampled schools.

Practical improvement should therefore prioritize manageable project scopes, non-digital alternatives to video resources, teacher guidance for assessing group processes, and culturally appropriate collaboration with knowledge holders. An electronic platform may extend access to expertise, but it should not become a precondition for learning in poorly connected locations. Research on online project learning and engagement, such as Zen et al. [45], concerns a different education level and measured outcome, making direct comparison with these Grade VII competency results inappropriate. Likewise, Sharma et al. [46] show the broader relevance of applied projects in engineering education without establishing the same effects in local-content classrooms. Experiences reported by Tsybulsky and

Muchnik-Rozanov [47] further emphasize that teachers' emotional and professional adjustment deserves attention when pedagogical roles change from direct explanation to facilitation.

4.5 Methodological Limits and Future Research

The principal methodological limitation is that instructional conditions were assigned by school, whereas the reported ANOVAs treated 150 student records as independent. Six schools—two in each condition—provide too few clusters to recover a reliable school-adjusted test from summary data. Group differences may reflect school, teacher, selection, and baseline characteristics, as well as differing curriculum resources. Although a pretest–posttest procedure was planned, matched participant-level pretest and posttest files are not available within the reported effectiveness tables; causal change scores and baseline-adjusted comparisons are therefore not provided. Skewness and an extreme problem-solving value in one comparison group have not been inspected at record level. Cross-school assessor reliability, scoring conversion rules, fidelity logs, and classroom-level implementation evidence are incomplete. Additionally, the dissertation summary gives alternative means that conflict with the complete statistical output, requiring author-led reconciliation. Nominal significance results should thus not be treated as causal evidence of superior instruction.

Research extending this intervention should document the consent and authority of community knowledge holders, the origin of each cultural element, and the boundaries of what may be shared publicly. Predefined school-level allocation and sufficient numbers of schools would allow cluster-aware inference, while baseline measures, common assessment materials, clear scale conversion, assessor calibration, and reported reliability would improve validity. Fidelity checklists and examples of authentic student work could establish which PjBL processes occurred and how they relate to the two outcomes. Qualitative observation would help test whether context familiarity affects reasoning or group coordination rather than simply accompanying higher scores. Where permission allows, de-identified pupil and school records could enable independent robustness checks.

5. Conclusion

The findings provide descriptive evidence that students in schools implementing Abun conservation-oriented PjBL achieved higher assessed problem-solving and collaboration scores than those in the two comparison conditions. However, school-level confounding and the absence of cluster-adjusted analyses prevent definitive causal conclusions. The principal contribution is the documented integration of Indigenous Abun knowledge into planned project-based learning and competency assessment.

The school-based comparison showed that the Abun conservation-oriented PjBL condition had the highest observed mean problem-solving and collaboration scores (78.02 and 74.28), followed by school-developed PjBL (68.82 and 63.48) and conventional instruction (59.70 and 50.32). These results describe score differences associated with school-assigned instructional conditions and cannot isolate the contributions of Abun knowledge, project pedagogy, teacher practice, or school context. The two-

PjBL comparison is informative for future research but is not a causal estimate of cultural contextualization.

The more directly documented contribution is a curriculum-design pathway linking Abun cultural sources and conservation problems to inquiry, group planning, maps, performances, and proposed multimedia and craft outputs. Expert appraisal and limited pilot responses indicate perceived suitability and practicality, while lesson time, literacy demands, internet access, and attendance restricted implementation.

The original pupil-level ANOVA and LSD tests are retained transparently, but their nominal p values and intervals do not account for school clustering. Baseline equivalence, school-specific performance, and scoring reliability remain incompletely documented. Future research requires community-authorised sources, observable implementation evidence, and a sufficiently powered school-aware design to distinguish pedagogical mechanisms from institutional differences.

Declarations

Competing Interests

The authors declare no competing interests

Ethics approval and consent to participate

This study was institutionally approved as part of the corresponding author's doctoral research at Universitas Negeri Malang, Indonesia. The ethical documentation for the study was subsequently reviewed and approved by the Research Ethics Committee of Universitas Negeri Malang, Indonesia, under Institutional Review Board Reference No. 16.10.5/UN32.14/PB/2026, dated 16 October 2026. The study was conducted in accordance with the applicable institutional requirements for doctoral research at Universitas Negeri Malang and with the Ethical Safeguards and Participant Protection provisions confirmed by the Education, Youth and Sports Office of Tambrauw Regency, Southwest Papua Province, Indonesia (Reference No. 420.809.2 026, dated 16 October 2026). These provisions included voluntary participation, parental or legal guardian informed consent, age-appropriate student assent, confidentiality and data protection, protection of students' educational welfare, and respect for Indigenous Abun cultural knowledge and customary practices through appropriate consultation and authorization by relevant community representatives. The participants were 150 Grade VII students aged 10–14 years. Informed consent to participate was obtained from the parents or legal guardians of all participating students, and age-appropriate assent was obtained from the students.

Consent for publication

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Author Contribution

Tenia Kurniawati conducted the doctoral research, including the development of the research framework, implementation of the study, and preparation of the original research materials and findings. Punaji Setyosari provided doctoral supervision and academic guidance throughout the research process. Dedi Kuswandi contributed to doctoral supervision and provided methodological and academic guidance. Henry Praherdhiono contributed to doctoral supervision and provided guidance on the development and implementation of the educational research. Mafrur Udhif Nofaizzi was responsible for preparing and drafting the journal manuscript, organizing the research findings into the article structure, and revising and editing the manuscript for scholarly publication.All authors reviewed and approved the final version of the manuscript and agreed to be accountable for its content.

Data Availability

The datasets generated during and/or analysed during the current study are not publicly available due to participant privacy and confidentiality considerations. but are available from the corresponding author on reasonable request.

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Figures

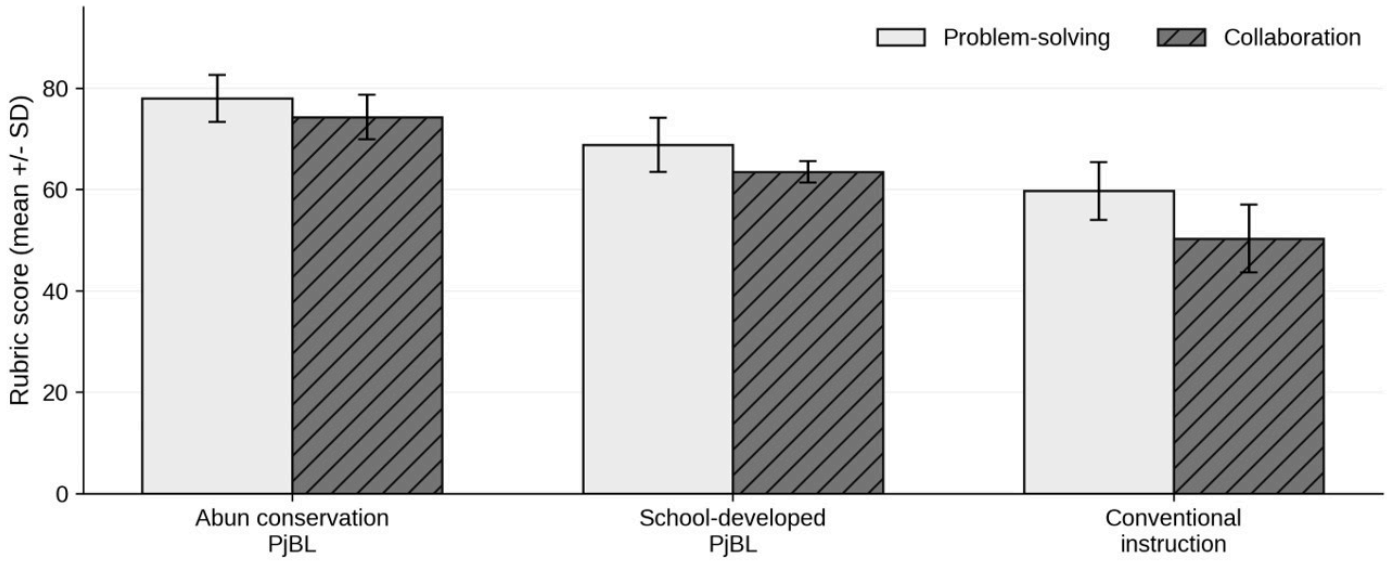

Figure 1

Mean rubric scores and sample standard deviations by school-assigned instructional condition