



Development of IPAS Instructional Materials Based on Project-Based Learning (PjBL) for Sixth-Grade Elementary Students

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Abstract: This study developed Project-Based Learning (PjBL) instructional materials for Grade-6 IPAS (Integrated Science and Social Studies) using Plomp's development model. The process followed three consolidated phases: (1) preliminary investigation (curriculum analysis, learner characteristics, learning needs, and review of existing materials); (2) design and construction producing Prototype 1, followed by expert validation of content, language, and media with iterative revision; and (3) test-evaluation-revision, including practicality trials (one-to-one, small group, and field) and descriptive checks of learning outcomes. Mean expert validity was 89.7% on a 0–100% scale. Practicality rose from 78% (one-to-one) to 86% (small group) and 91% (field), placing the materials in the very practical category at field testing ($\geq 90\%$). During classroom implementation, average student engagement was 87%, and 93% of students met classical mastery on the post-test. The findings indicate high validity ratings and very high practicality for classroom use; outcome data show strong post-test attainment and engagement but do not evidence improvement in the absence of a pre-test or control comparisons. In conclusion, the PjBL-based IPAS materials are feasible for Grade-6 implementation and merit further effectiveness studies using pre-post or comparative designs.

Keywords: Elementary IPAS education; Instructional material development; Project based learning (PjBL)

Introduction

Elementary school science (IPAS) instruction requires printed teaching materials that are well-structured, contextual, and easy for teachers to implement. Teaching materials are not merely compilations of information but are instruments that organize the learning flow, prompt meaningful interaction, and spark student curiosity. This is especially crucial in early to middle grades, where the printed format remains the most accessible and readable option across diverse classroom settings (Maulidah et al., 2024).

Research evidence indicates that differentiated teaching materials can strengthen critical thinking skills and deepen student engagement with the subject matter. In the context of IPAS, differentiated materials have been shown to enhance the critical thinking of elementary students. Furthermore, argumentation-based materials help sustain student attention and support teachers in enacting the curriculum more independently (Fasha & Sopandi, 2024).

Interactive and technology-enhanced resources can also improve academic performance and the retention of complex concepts. Studies reporting learning gains from technology-assisted materials underscore the value of a

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well-planned integration of digital elements to complement core printed resources. This is illustrated in hybrid application designs for IPAS that position appropriate teaching materials as the foundation for conceptual growth (Saputro et al., 2024).

Well-designed teaching materials foster an engaging learning environment and sustain student motivation. Contextual resources that connect to learners' everyday experiences make abstract ideas tangible and link school knowledge to real-world situations, ultimately improving motivation and learning outcomes (Anggraeni et al., 2023; Lafifa et al., 2023).

Diverse media formats support different learning preferences and can deepen student engagement. Integrating text, images, and video offers multi-faceted pathways for understanding content. Moreover, interactive elements embedded within e-modules have been associated with higher levels of engagement and improved learning outcomes (Haniah et al., 2023; Mulu et al., 2022).

Despite the proliferation of digital options, printed modules and worksheets remain highly relevant in elementary education. When augmented with structured activities and optional QR code links to supplementary videos, print materials can maintain student interest and boost learning outcomes. Furthermore, systematic validation ensures that such materials are enjoyable and accessible for young learners (Hayati et al., 2022).

Local classroom observations at SDN 07 Sitapung indicate that existing IPAS materials are generic, lack interactive features, and omit project-based activities. Teachers report low student activity levels when the content is disconnected from daily experiences. In contrast, students express greater enthusiasm for colorful, illustrated materials that include hands-on tasks, such as building simple ecosystem models. These findings point to an urgent need for contextual, visually engaging, project-based printed materials for Grade VI.

Consequently, the objective of this development is to create printed IPAS teaching materials on the ecosystem theme for Grade VI using a Project-Based Learning (PjBL) approach that are content-valid, practical for teachers, and ready for initial classroom trials. The specific aims are to identify user and contextual needs, design prototypes comprising a student module, worksheets, and a teacher guide that lead to meaningful projects, validate the content and implementability through expert review and limited trials, and refine the design for initial implementation.

To achieve these aims, the development will follow the Plomp model, framed into the phases of Design, Realization/Construction, and Evaluation. A needs analysis through observations and interviews will form

the basis of the Design phase. Iterative self-evaluation, expert appraisal, and small-group trials will guide the Realization/Construction phase. Meanwhile, the Evaluation phase will encompass aspects of validity, practicality, and indications of effectiveness in classroom settings. Such a structured framework has been associated with stronger outcomes in terms of validity and practicality (Plomp & Nieveen, 2013).

Method

This study adopts a research and development (R&D) approach to produce and evaluate a specific educational product. In line with Sugiyono (2019), R&D is used both to develop the product and to test its effectiveness. Rather than proposing a new theory, the study develops a learning model and subjects it to field trials to establish its validity, practicality, and effectiveness. The development process follows Plomp's model, comprising five phases: (1) Preliminary Investigation, (2) Design, (3) Realization/Construction, (4) Test, Evaluation, and Revision, and (5) Implementation (Plomp, 2007).

The development process follows the Plomp educational design research model, which consists of five sequential phases (Plomp & Nieveen, 2013), as visualized in the following flowchart:

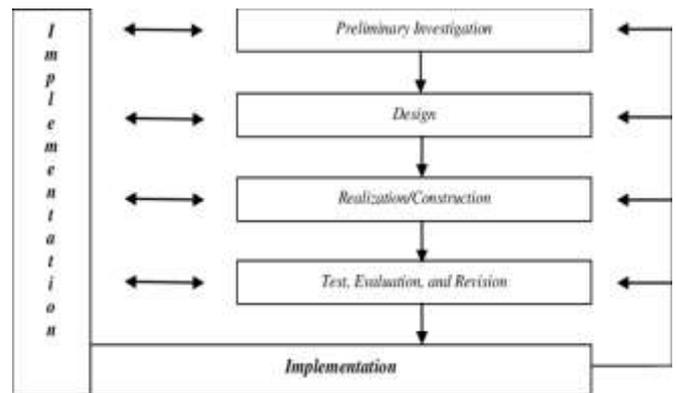


Figure 1. Schematic of the Plomp educational design research model

Participants and Setting. This study involved sixth-grade students and their homeroom teachers from three public elementary schools in Agam Regency (including SDN 07 Sitapung). Participants took part in both limited trials and full field trials. Instruments and Data Collection. Data were gathered using expert validation sheets, classroom observation sheets, teacher and student response questionnaires, and evaluation sheets. Data collection techniques comprised science process skills tests, classroom observations, questionnaires, and field notes.

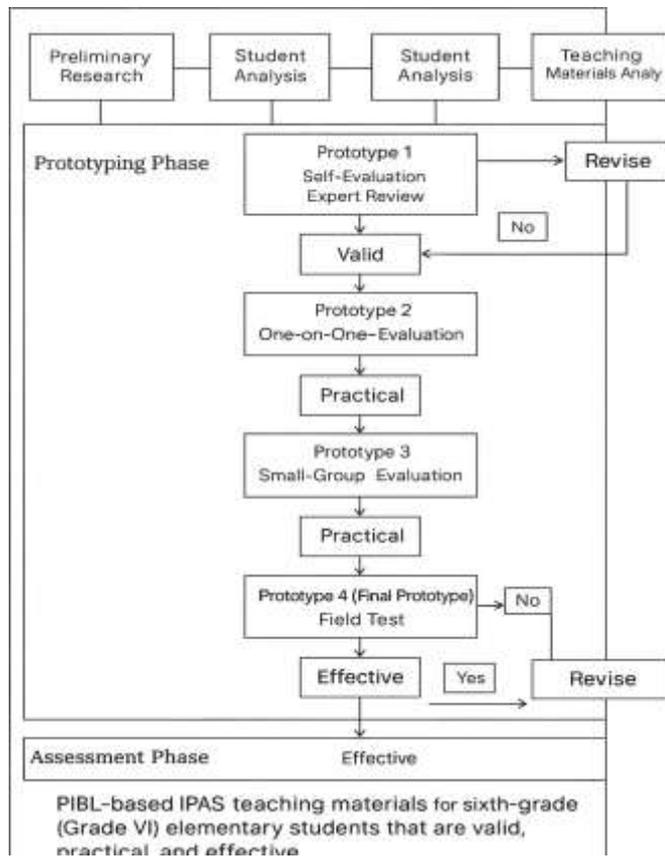


Figure 2. Development process

The data were analyzed using descriptive statistics (means and percentages) as outlined by Boslaugh (2012). Expert validators completed a validation instrument to judge the product. Their ratings were analyzed using Aiken’s V index (Aiken, 1985), computed as:

$$V = \frac{\sum s}{n(c-1)}, \text{ with } s = r - l_0 \quad (1)$$

Description

V: index of agreement on item validity

r: score assigned by a validator

l_0 : lowest score on the rating scale

s: difference score ($r - l_0$)

n: number of validators

c: number of categories on the scale

Following Azwar (2012), the validity decision rule for Aiken’s V is shown in Table 2.

Table 1. Aiken’s V Index Criteria (Azwar, 2012)

Aiken’s V	Validity
$V < 0.80$	Invalid
$V \geq 0.80$	Valid

Practicality Evaluation

Practicality was assessed using student response questionnaires and questionnaires for chemistry

teachers, plus a teacher-activity observation sheet to document implementation in class (Nieveen, 1999). The practicality percentage was calculated as:

$$NP = \left(\frac{R}{SM}\right) \times 100 \quad (2)$$

Description: NP = percentage, R = obtained score, SM = maximum score. The interpretation thresholds follow (Akbar, 2013) (Table 3).

Table 2. Practicality Level Criteria (Akbar, 2013)

Interval	Criteria
86%-100%	Very Practical
76%-85%	Practical
60%-75%	Fairly Practical
55%-59%	Less Practical
$\leq 54\%$	Not Practical

To evaluate the effectiveness of project-based learning (PjBL) media in enhancing student learning outcomes, the assessment is conducted through tests using objective question formats.

$$\text{Effectiveness Score} = \frac{\text{Total Score Obtained}}{\text{Maximum Possible Score}} \times 100\% \quad (3)$$

To determine the improvement in student learning outcomes, the difference between the pre-test and post-test scores is calculated. The difference between the two tests is called the Gain. The formula for calculating N-gain is shown in equation 1 (Andini & Fitria, 2021). The next step involves presenting the results of the N-Gain calculation using criteria as in table 3.

$$\text{N-Gain} = \frac{\text{Score Posttest} - \text{Skor Pretes}}{\text{Score Ideal} - \text{Skor Pretes}} \quad (4)$$

Table 3. N-Gain Interpretation Categories

N-Gain Value	Category
$\text{N-Gain} > 0.7$	High
$0.3 < \text{N-Gain} \leq 0.7$	Medium
$\text{N-Gain} \leq 0.3$	Low

To evaluate the effectiveness of the instructional media, the criteria are based on students’ IPAS learning outcomes as measured by their N-Gain scores. The interpretation of these scores is presented in the following table (Andini & Fitria, 2021):

Table 4. N-Gain Effectiveness Criteria

N-Gain Percentage Interval	Effectiveness Criteria
$< 40\%$	Ineffective
$40\% \leq \text{N-Gain} < 55\%$	Less Effective
$56\% \leq \text{N-Gain} \leq 75\%$	Moderately Effective
$> 75\%$	Effective

Results and Discussion

Preliminary Research

Need and Context Analysis

This study was conducted through interviews and classroom observations in Grade 6 IPAS at SDN 07 Sitapung, Agam District, which has implemented the Merdeka Curriculum. The goal was to identify problems and obstacles faced by teachers and students in learning the ecosystem topic. This preliminary study examines the readiness of IPAS ecosystem instruction in Grade VI at SDN 07 Sitapung through analysis of the Merdeka Curriculum documents, interviews with six homeroom teachers, limited classroom observations, and a review of teaching materials used in practice.

Curriculum Analysis. Referring to Permendikbudristek No. 12 of 2024, the learning outcomes for Phase C require students to identify ecosystems, explain relationships between biotic and abiotic components and their effects, and produce simple artifacts (e.g., models/dioramas) via project-based approaches. Initial findings show alignment with PjBL, but implementation of project activities remains limited.

Learner Characteristics. Students are 10–12 years old, prefer visual and colorful materials, and can collaborate in groups. Academic ability is heterogeneous; some require repetition to grasp concepts. Student interviews confirm preferences for concise, clear, illustrated, and easy-to-follow resources.

Needs Analysis. Existing materials do not optimally stimulate inquiry and projects; experimental procedures are insufficiently explicit, limiting participation and independent learning. An IPAS PjBL module is needed that is contextual, visual, and provides step-by-step procedures plus formative assessment of science process skills.

Analysis of Existing Teaching Materials. Two legacy textbooks and a teacher-created module offer basic content but generally lack experiments/projects, provide limited activity guidance, and are weak in visual design. This supports the need to develop a new module with richer experimental/project activities and improved visual appeal.

Development of Conceptual Framework

Development, or prototyping, is a research microcycle. This development, or prototyping, will result in stages, namely Prototype I, Prototype II, Prototype III, and Prototype IV, which are formative evaluation results.

Prototype I

The Prototype I stage is to design and develop teaching materials to support independent curriculum

learning on ecosystem material in Phase C. The components of the teaching materials are the deepening of ecosystem material, supporting information, and practice questions. In the teaching materials, there are instructions that can provide information about the book's contents, such as a preface, concept map, sample questions and discussion, activities, comprehension tests, and ecosystem literacy.



Figure 3. Previous instructional materials

Prototype II

Prototype II is the result of the formative evaluation of the self-evaluation of Prototype I. At this stage, researchers checked the completeness of the teaching material components. From the results of the self-evaluation, the design and components of teaching materials and student activities in the teaching materials that have been developed are complete, so no revisions are needed to Prototype I.

Prototype III

Prototype III results from a formative evaluation from an expert review and a one-to-one evaluation from Prototype II. At the expert review stage, the assessment instrument used was a validation questionnaire. Validation data were obtained from three science (IPAS) lecturers and two science (IPAS) teachers. Several suggestions and inputs were obtained from the results of validation with experts that could be used as guidelines in revising Prototype II, namely: (1) some pictures are still unclear, and (2) the need to add examples of ecosystem material related to everyday life. The data that have been obtained will be processed using Aiken's V scale. From the data processing, the validity value of the development of teaching materials to support independent curriculum learning on ecosystem material with an average of 0.85, categorized as valid, was obtained. These results indicate that the development of teaching materials is valid regarding content, presentation, language, and graphics. The validation results can be seen in the following bar chart.

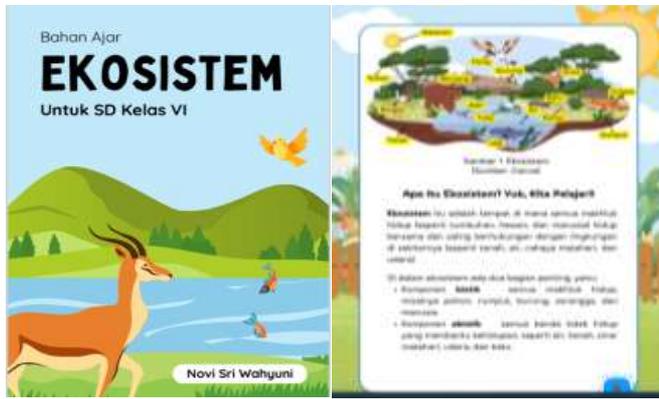


Figure 4. Teaching materials after revision

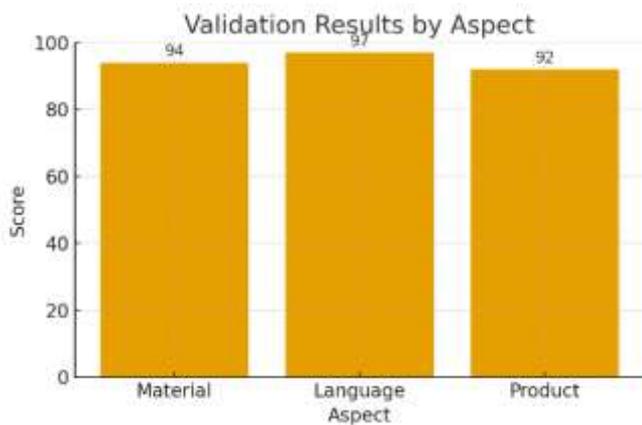


Figure 5. Validity value

Validity Evidence. Product quality is demonstrated not only by the adequacy of the developed materials but also by empirical evidence of validity (Khasanah et al., 2019). Expert validation covered three aspects: Material, Language, and Product, and yielded scores of 94, 97, and 92, respectively, each classified as Very valid. The average score was 94 (Very valid), indicating that the ecosystem teaching materials for Grade 6 meet standards for content accuracy and coverage (Material), clarity and readability (Language), as well as design and usability (Product) (Kartini et al., 2019). These results provide a strong basis to proceed to practicality testing with teachers and students.

Table 5. Student Practicality

Evaluation Phase	Students	Score	Category
Prototype 2 (One-to-One)	3	78%	Practical
Prototype 3 (Small Group)	6	86%	Very Practical
Prototype 4 (Field Test)	20	91%	Very Practical

In the Prototype 2 (One-to-One) stage, the media was tested individually with 3 students, resulting in a practicality score of 78%, which falls into the "Practical" category. This phase provided early feedback for revisions. Next, the Prototype 3 (Small Group) was tested with 6 students, achieving a score of 86%,

indicating a "Very Practical" category. This stage showed improved effectiveness and usability after revision. Finally, Prototype 4 (Field Test) involved 20 students in a classroom setting and reached a score of 91%, which also falls under the "Very Practical" category.

Implementation (Assessment Phase)

This phase analyzes the effectiveness of the PjBL-based IPAS teaching materials implemented in Grade VI, SDN 07 Sitapung, Ampek Angkek, Agam with 20 students. Effectiveness was assessed using two indicators: (1) student activity during learning and (2) cognitive learning outcomes after learning with the materials.

Student Activity Analysis

Observed activity covered six dimensions adapted from Sartika (2018): Emotional Activities, Motor Activities, Visual Activities, Oral Activities, Mental Activities, and Writing Activities. Average achievements across meetings were: Emotional 100%, Motor 88%, Visual 83%, Oral 86%, Mental 83%, Writing 87%. The overall average was 89%, classified as very effective. Each observed meeting reached the "very effective" criterion.

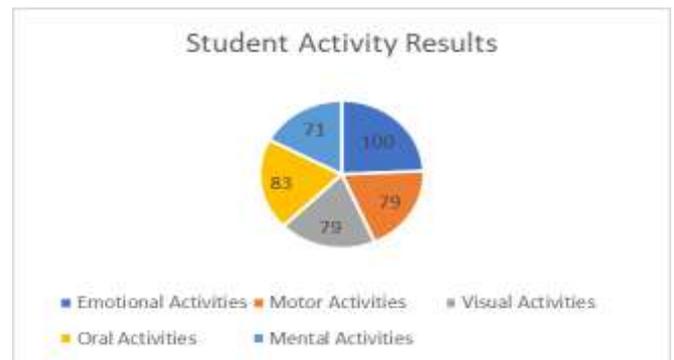


Figure 6. Student activity

Cognitive Learning Outcomes (N-gain)

From the recap: pre-test mean = 60.5, post-test mean = 93.0. The N-gain = 0.76 (76.2%), which falls in the high category (g > 0.7). This indicates a substantial improvement in students' understanding of IPAS concepts, particularly the ecosystem subtopic, after using the PjBL materials.

The PjBL-based IPAS module used in Grade VI at SDN 07 Sitapung is an inquiry-oriented approach designed to build students' scientific thinking in authentic problem solving. Students take an active role—planning, carrying out, and reflecting on project tasks—while the teacher acts as a facilitator who poses meaningful problems, curates resources, and guides discussion, with direct intervention kept to a minimum. This orientation gives students space to practice

questioning, hypothesizing, explaining, and reasoning with evidence, in line with the goals of elementary science learning to develop knowledge, ideas, and their application to everyday problems.

Table 6. Recapitulation of N-Gain Test Results

Class	Description	Session 1	Session 2
		Pre-Test	Post-test
VI	Total	1210	1860
	Mean	60.5	93
	N-Gain (g)		0.76
	N-Gain (%)		76.2%
	Category	"high" $0.76 \leq 0.7$	

Effectiveness was evaluated with 20 students through two indicators: classroom activity and cognitive outcomes. Observation across six activity dimensions (Emotional, Motor, Visual, Oral, Mental, Writing) showed high engagement: Emotional 100%, Motor 88%, Visual 83%, Oral 86%, Mental 83%, and Writing 87%, with an overall average of 89% classified as very effective. Learning gains were also substantial: the class mean increased from 60.5 (pre-test) to 93.0 (post-test), yielding an N-gain of 0.7628 (76.2%), categorized as high. Taken together, these data indicate that the PjBL-based IPAS module effectively improves both student activity and cognitive learning on the ecosystem topic.

Conclusion

This study developed a PjBL-based IPAS ecosystem module for Grade VI at SDN 07 Sitapung. Expert validation indicated very valid quality (Material 94, Language 97, Product 92; average 94). Practicality testing showed very practical use for students (mean 93%) and teachers (mean 86%). Classroom implementation yielded very effective student activity (mean 89%) and high learning gains (N-gain = 0.7628; mean score improved from 60.5 to 93.0). These results indicate that the module is valid, practical, and effective for supporting ecosystem learning in Grade VI. Limitations include a single-class sample; broader trials are recommended.

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Author Contributions

Conceptualization, N.A. and R.F.; methodology, N.A.; software, N.A.; validation, N.A., R.F. and L.M.; formal

analysis, N.A.; investigation, N.A.; resources, N.A.; data curation, N.A.; writing—original draft preparation, N.A.; writing—review and editing, N.A.; visualization, N.A.; supervision, R.F.; project administration, N.A.; funding acquisition, R.F. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

No conflict interest.

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