



## Development of a Coconut Coir Waste-Based Learning Medium (Ecowaste) to Improve Students' Learning Outcomes

Nurul Fadillah Hasibuan\*, Zainuddin Muchtar

Department of Elementary School Teacher Education, Universitas Negeri Medan, Medan, Indonesia

\*Corresponding Author: [nurulfadillah1705@gmail.com](mailto:nurulfadillah1705@gmail.com)

### Abstract

Suboptimal classroom instruction can make content difficult to grasp and reduce students' focus and interest, a problem compounded by the limited use of a learning medium. This study aimed to develop a coconut coir waste-based learning medium (Ecowaste) to improve students' learning outcomes in Integrated Science and Social Studies (IPAS). We evaluated the feasibility, practicality, and effectiveness of the Ecowaste learning medium in Grade V at SDN 200206 Padangsidempuan using a Research and Development approach with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). Content expert validation reached 92% ("very feasible"), and media expert validation reached 91.4% ("very feasible"). Teacher practicality was 90% ("very practical"), and student responses averaged 86.35% ("very good"). The mean pretest score was 58.25%, increasing to 86.5% on the posttest after using the learning medium, which falls into the "Effective" category. These results indicate that the coconut coir waste-based learning medium (Ecowaste) is feasible, practical, and effective for improving students' learning outcomes.

**Keywords:** Coconut coir waste; Learning medium; ADDIE model; Feasibility; Effectiveness; Students' learning outcomes

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### INTRODUCTION

Education is a deliberate and structured effort to develop human capacities in ways that matter for individuals and society. In Indonesia, policy frames education as a conscious process that enables holistic growth across spiritual, emotional, intellectual, moral, and practical dimensions. This definition sets a clear expectation that schools design learning experiences that foster whole-person development rather than narrow test preparation. The expectation is reasonable, yet many classrooms still struggle to translate it into daily practice. When instruction remains teacher centered, minimally mediated by concrete tools, and weak in connecting content to students' lived contexts, focus, engagement, and conceptual understanding predictably suffer.

The demands of twenty-first-century learning sharpen these challenges. Classrooms are expected to cultivate flexible thinking, creativity, communication, and problem solving. The Merdeka Curriculum was introduced to respond to this reality by expanding the autonomy of schools and teachers to design contextual, student-centered learning (Fitra, 2023). The supporting claim is that greater professional latitude helps teachers tailor instruction to local needs, integrate community resources, and vary learning media and methods to reach diverse learners. A counterpoint is equally clear: autonomy by itself does not guarantee improvement. Without teacher capability, relevant learning media, and

assessments that value understanding and transfer, autonomy risks reproducing old routines with new terminology. In this policy frame, a learning medium is not ornamental. It functions as a bridge between abstract ideas and concrete experiences that students can see, handle, and discuss, which is the kind of mediation student-centered learning requires.

Environmental literacy is a domain where such mediation is both timely and necessary. Human well-being depends on ecological integrity, and schools carry a dual responsibility: build conceptual understanding of environmental systems and cultivate dispositions and routines that make stewardship actionable. The everyday reality is less than ideal. Many students still dispose of waste improperly, a habit that degrades local environments and puts health at risk. Some may argue that students mirror community norms, so school-based interventions have limited leverage. This concern matters, but it does not absolve schools of responsibility. It points instead to the need for learning that is hands-on, locally grounded, and problem oriented so that environmental content connects to choices students make daily (Yuliana, 2022).

Waste management offers a practical route for such contextualization. Waste is not only an environmental burden; it also reflects consumption patterns and behaviors. As living standards and human activities change, both the volume and the types of waste evolve. If managed wisely, waste can become an alternative resource with economic and educational value (Harimurti et al., 2020). Turning waste into usable learning materials brings environmental issues to the classroom table while modeling reduction and reuse. Coconut coir waste is an apt example in many Indonesian communities. Coconut products are ubiquitous, leftover coir is abundant, and it is often discarded or underutilized. Integrating coconut coir into a learning medium can anchor classroom content in local realities, stimulate curiosity through tactile exploration, and open discussion about material cycles, value, and stewardship. A fair challenge is whether such materials meet standards for safety, durability, and instructional usefulness. That challenge should be answered by systematic development and evaluation rather than assumptions.

Recent literature on materials science strengthens the case for coconut coir as a candidate for classroom use. Coconut coir, derived from the outer husk of coconuts, is a lignocellulosic material with notable fractions of lignin, cellulose, and hemicellulose that confer useful mechanical properties (Destyorini et al., 2022; Fernando et al., 2025). These properties have made coir attractive for diverse applications, including as a growth medium in horticulture where water retention, aeration, and structural stability are relevant (Zheng et al., 2024; Gamage et al., 2022). Importantly for schools, coir is biodegradable and non-toxic, qualities that align with educational initiatives aimed at cultivating environmental consciousness among students (Stelte et al., 2022). One might worry that raw agricultural byproducts are messy or inconsistent. That risk is real, but it can be addressed by simple preparation protocols and by selecting uses that match the material's affordances.

Emerging work also points to the pedagogical value of coir in educational settings. Studies that use coir to support seedling growth provide a tangible platform to discuss plant physiology, resource cycles, and experimental observation in classrooms (Chromkaew et al., 2023). More broadly, classroom use of

repurposed natural materials can model sustainable practices in agriculture and waste management, reinforcing environmental stewardship and resource mindfulness among young learners (Stelte et al., 2018; Bradley & Conroy, 2019). The implication is not that any "green" material will automatically improve learning. Rather, materials like coir can enable hands-on tasks that are aligned with curricular goals, provided teachers scaffold the work and assessments target understanding rather than novelty effects.

Integrated Science and Social Studies (IPAS) provides a natural curricular space for such work because it weaves scientific ideas with social applications. Yet preliminary evidence from the target school, SDN 200206 Padangsidempuan, indicates that Grade V IPAS lessons have not consistently supported focus, participation, or mastery. Based on teacher interviews and classroom observations, instruction is often delivered with minimal use of learning media, which makes content delivery feel monotonous and harder to grasp. Students struggle to sustain attention and to make sense of new ideas. Assessment data are consistent with this picture: of twenty students, only seven reached the mastery criterion, while thirteen did not. No single factor explains these outcomes, but the limited use of engaging learning media likely contributes to cognitive overload, low motivation, and the absence of concrete referents that help students connect prior knowledge to new content.

Research on learning media clarifies why appropriate media matter. Well-designed media distribute cognitive effort by externalizing information, enable dual coding through verbal and nonverbal channels, and provide scaffolds for active processing. In practice, students see and handle objects, make observations, test ideas, and receive immediate feedback from the materials themselves. Scholars have emphasized that media are not ends in themselves; they function when aligned with learning goals and when teachers orchestrate tasks that require analysis, communication, and reflection (Cahyani et al., 2023). The teacher's role does not vanish in a media-rich classroom. The teacher curates experiences, poses questions, and helps students interpret what they do with the materials. There is a legitimate concern that media can distract or remain superficial if misused. The case for a learning medium is conditional, then: it strengthens when the design is purposeful, the tasks are meaningful, and teacher facilitation is attentive (Apriyani & Sitohang, 2022).

Against this backdrop, the present study introduces and examines the Ecowaste learning medium, a coconut coir waste-based learning medium designed for Grade V IPAS. The premise is practical. First, coconut coir waste is locally available, low cost, and environmentally relevant, which supports feasibility in the school context. Second, embedding coir-based components in lesson tasks can make abstract IPAS content more concrete and experiential, which supports practicality for daily teaching. Third, if the medium structures active engagement and supports conceptual understanding, we should observe gains in students' learning outcomes that meet recognized effectiveness criteria. A skeptical reader might say that such a medium could raise attention without deepening understanding. That concern is valid, so the design and evaluation in this study focus on measurable indicators of feasibility, practicality, and effectiveness rather than surface engagement alone.

The study adopts a Research and Development approach organized through the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation. During analysis, we identify learner needs, curriculum targets, and classroom constraints at the partner school. During design, we specify learning goals, coir-based components, task sequences, and assessment rubrics. During development, we build prototypes, conduct expert reviews for content and media quality, and revise iteratively. Implementation occurs in Grade V IPAS lessons with a practicing teacher and real students. Evaluation then draws on expert validation scores, teacher practicality ratings, student response surveys, and pretest to posttest achievement measures. This sequence is not novel, but it offers a disciplined pathway from idea to classroom-ready product with documented evidence at each step.

Several features frame the study's expected contribution. First, the learning medium is grounded in a locally abundant waste material, which aligns environmental education with real community resources rather than imported solutions. This moves beyond generic calls to use media by showing how a neglected material can be repurposed pedagogically for core IPAS content. Second, the evaluation is multi-criterion. We do not infer effectiveness from enthusiasm or anecdote; we collect expert feasibility judgments for content and media, analyze practicality from a teacher's perspective, record student responses, and measure learning gains using a pretest to posttest design with attention to established gain categories. Third, the work is situated in a real Grade V classroom, which surfaces practical constraints and teacher mediation issues that laboratory studies often overlook. The limitations are clear: a modest sample constrains generalization, teacher facilitation can shape outcomes, and novelty effects are possible. Making these limits explicit positions the findings as design-based evidence suitable for refinement and replication rather than sweeping claims.

Operational definitions keep the analysis precise. A learning medium is any designed tool or set of materials that mediates interaction between learner and content by enabling representation, manipulation, and feedback. Feasibility refers to expert validation of content accuracy, alignment with IPAS competencies, clarity of instructions, and suitability of the coir-based components for classroom use. Practicality refers to teacher judgments of preparation demands, classroom management, time efficiency, and fit with routine lesson structures, as well as student response patterns regarding interest and perceived usefulness. Effectiveness refers to improvement in students' learning outcomes from pretest to posttest as summarized by normalized gain categories commonly used in classroom research. These definitions prevent ambiguity when interpreting results and help ensure that claims align with the instruments actually used.

The school context further justifies the design choices. SDN 200206 Padangsidempuan serves learners whose exposure to hands-on IPAS activities and structured use of learning media has been limited. Grade V students are developmentally ready to engage in extended, tactile tasks while still benefiting from concrete materials. The coconut coir components are aligned with IPAS topics that invite exploration of natural materials, their properties, and their human uses. Cost and ease of assembly are integral to the design. For adoption to be realistic, teachers must be able to reproduce the medium with reasonable effort using locally

available materials. If a design depends on specialized tools, uptake will be rare. Coir-based components can be sourced and assembled with basic tools and clear instructions, which strengthens the argument for practicality if instructional benefits are demonstrated.

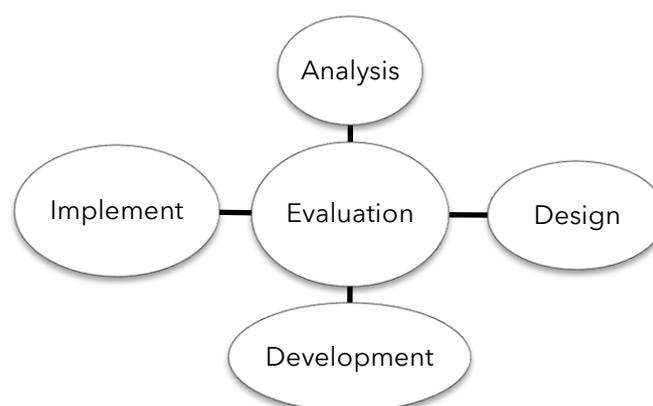
The problem statement guiding this work is twofold. First, classroom observations and assessment data indicate low mastery and limited engagement in Grade V IPAS, suggesting a need for more effective mediation between content and learners. Second, there is a lack of locally grounded learning media that simultaneously address environmental stewardship and conceptual understanding in IPAS. The study proposes to address these problems by developing the Ecowaste learning medium and examining its feasibility, practicality, and effectiveness in the target setting. From a design standpoint, the key question is not whether coconut coir is interesting, but whether a coir-based learning medium can be built and used in ways that reliably support the intended learning outcomes.

In line with this framing, the purposes of the study are to develop and evaluate a coconut coir waste-based learning medium for Grade V IPAS at SDN 200206 Padangsidempuan. The evaluation focuses on three questions. First, to what extent does the learning medium meet expert criteria for content and media feasibility. Second, to what extent do teachers and students judge the medium as practical and valuable for everyday lessons. Third, to what extent does the medium support improvement in students' learning outcomes as indicated by pretest to posttest measures and recognized gain categories.

## METHODS

Research and development is a method used to design and produce a product that matches user needs. The initial stages emphasize a rigorous needs analysis, while subsequent stages focus on testing product effectiveness so that the product can be used optimally in broader contexts (Slamet, 2022).

This study employed a research and development design using the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation (see Figure 1). In the Analysis stage, we examined needs through interviews and classroom observations, conducted a curriculum and content analysis aligned with Integrated Science and Social Studies (IPAS), and analyzed learner characteristics. In the Design stage, we specified the structure and components of the coconut coir waste-based learning medium, including learning objectives, task sequences, and assessment plans.



**Figure 1.** Flowchart of the ADDIE development model

In the Development stage, we produced the prototype and conducted expert validations by a content expert and a media expert to establish feasibility. In the Implementation stage, we examined practicality through teacher use and student responses, and we assessed effectiveness in terms of students' learning outcomes in Grade V. In the Evaluation stage, we reviewed evidence from feasibility, practicality, and effectiveness to refine the learning medium and to determine its readiness for classroom use.

The study was conducted at SD Negeri 200206 Padangsidimpuan, located on Jalan Alboit Hutabarat, Kampung Darek, Padangsidimpuan City, during the even semester of the 2024/2025 academic year. The evaluation covered content validity by a content expert and media validity by a media expert, as well as practicality judged by the classroom teacher and Grade V students. Expert and user judgments were collected using Likert-scale questionnaires with five categories: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree) (Sugiono, 2013).

The research instruments comprised interviews, questionnaires, and tests. The data included both qualitative and quantitative evidence. Qualitative data were derived from expert and teacher appraisals of the developed learning medium. Quantitative data were obtained from Likert-scale ratings. Media effectiveness was calculated using the N-Gain statistic, and all computations were carried out in Microsoft Excel.

The percentage score for content experts, media experts, the teacher, and student responses was calculated using the following formula (Bakri, 2015):

$$\text{Percentage score} = \frac{\sum \text{obtained scores}}{\sum \text{maximum scores}} \times 100\%$$

The percentage score expresses how close an observed rating comes to the maximum possible rating on a given instrument. It is computed by dividing the sum of all obtained scores (the actual points earned across items, raters, or respondents) by the sum of all maximum scores that could have been earned on those same items, then multiplying by 100% to convert the ratio to a percentage.

The validity criteria for the media and content are presented in Table 1. Percentage scores from expert and user evaluations are mapped to feasibility categories using thresholds adapted from Ernawati (2017), ensuring consistent interpretation across instruments and raters. To prevent overlap during analysis, the operational ranges are applied as shown in Table 1.

**Table 1.** Validity criteria for media and content

Percentage	Category
>20%	Very Infeasible
21% - 40%	Infeasible
41% - 60%	Fairly Feasible
61% - 80%	Feasible
81% - 100%	Highly Feasible

Table 1 presents percentage-based feasibility bands to ensure consistent interpretation across raters: results at or below 20 percent are categorized as Very Infeasible; 21-40 percent as Infeasible; 41-60 percent as Fairly Feasible; 61-80

percent as Feasible; and 81–100 percent as Highly Feasible for media and content evaluations. These thresholds prevent overlap.

Measurement of students' learning outcomes can use the normalized gain (N-Gain). This statistic quantifies the improvement between the pretest and posttest. The N-Gain is calculated as (Oktavia et al., 2019):

$$G = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{maks}} - S_{\text{pre}}}$$

Where:

$S_{\text{post}}$  = post-test score

$S_{\text{pre}}$  = pretest score

$S_{\text{ideal}}$  = maximum score (ideal)

Furthermore, Table 2 presents the effectiveness criteria used to interpret students' learning outcomes after the intervention.

**Table 2.** Effectiveness criteria for learning outcomes

Percentage	Category
>40%	Not Effective
40-55	Less Effective
56-75	Effective
>76	Highly Effective

Percentage scores from assessments are grouped into four categories to provide a clear, comparable basis for judgment. For analysis, we apply non-overlapping bands as shown:  $\leq 40\%$ , 41–55%, 56–75%, and  $\geq 76\%$ .

Outcomes at or below 40 percent are classified as Not Effective, scores of 41–55 percent as Less Effective, 56–75 percent as Effective, and 76 percent or higher as Highly Effective. These categories help summarize post-intervention performance and support straightforward comparisons across classes or iterations while avoiding ambiguity at boundary values.

## RESULTS AND DISCUSSION

### Analysis Stage

The analysis stage is the entry point of the ADDIE development model. We conducted a needs analysis through interviews with the Grade V teacher at SD Negeri 200206 Padangsidempuan, a review of curriculum and content, and a learner analysis. The needs analysis indicated that learning media were rarely used in IPAS lessons, which was associated with students' weak comprehension and limited interest in classroom activities. The curriculum and content analysis ensured alignment between the proposed learning medium and the Grade V IPAS textbook content, with a focus on waste management using the 3R principles (reduce, reuse, recycle). The learner analysis examined students' learning styles, attitudes, and prior knowledge so that the resulting learning medium would fit the characteristics of the target learners.

### Design Stage

At this stage, we planned the learning medium to be developed. We began by preparing materials that matched the instructional plan, including a learning module, teaching materials, student worksheets, the learning medium, and learning assessments for IPAS Unit 8 "Bumiku Sayang Bumiku Malang." The chosen topic was

"Oh, My Environment Is Damaged," specifically the 3R waste management subtopic. We also prepared a flowchart and a storyboard for the envisioned product to guide the production process and maintain coherence across components.

### Development Stage

During development, we produced the initial version of the Ecowaste learning medium that utilizes coconut coir waste. The initial product underwent expert validation by faculty members at Universitas Negeri Medan. Based on the validation feedback, the product was revised to address content clarity, media quality, and classroom usability. The post-revision product was intended to be sufficiently feasible for deployment in the classroom to support teaching and learning activities.

### Media Validation

Validation results for content showed improvement from the first to the second round (Table 3).

**Tabel 3.** Hasil validasi materi dan media

No	Validator	Feasibility Percentage	Category
1.	Content Expert	92%	Highly Feasible
2.	Media Expert	91,4%	Highly Feasible

In the first round, the feasibility percentage reached 80 percent, which falls into the Feasible category. After revision, the second round increased to 92 percent, which falls into the Highly Feasible category. Media validation exhibited the same pattern. In the first round, the media feasibility percentage was 80 percent (Feasible). In the second round, after revisions, the percentage increased to 92 percent (Highly Feasible). These improvements indicate that expert feedback effectively guided refinements to both content and media aspects, bringing the Ecowaste learning medium to a level appropriate for classroom implementation.

### Product Revisions

The product underwent targeted revisions to strengthen conceptual clarity and classroom usability: we added concise, student-friendly definitions of reduce, reuse, and recycle; provided concrete examples that link each principle to daily school and home practices (for instance, reducing single-use packaging, reusing containers for classroom storage, and recycling paper offcuts for note cards); and expanded the procedural guidance into a complete, step-by-step sequence for converting coconut coir waste into liquid organic fertilizer. The revised procedure now specifies the required materials and approximate quantities, preparation and soaking steps, simple safety and hygiene reminders, suggested observation checkpoints (texture, odor, and color changes), and a basic schedule for monitoring and decanting the fertilizer. To support implementation, we also clarified the expected learning outcomes and embedded prompts for prediction, measurement, and reflection at key points in the activity so that teachers can more easily align the hands-on work with IPAS objectives on 3R waste management and evidence-based reasoning.

### Implementation Stage

#### Media Practicality

To evaluate the practicality of the learning medium, we involved the Grade V classroom teacher at SD Negeri 200206 Padangsidempuan. The evaluation used a

questionnaire comprising ten statements that captured the teacher’s perceptions of four aspects: content, presentation, language, and the contextual appropriateness of the medium during instruction. This practicality assessment was intended to document the educator’s response to ease of use, classroom manageability, and instructional fit. The teacher’s response is summarized in Table 4.

**Table 4.** Teacher response to the learning medium

Practitioner	Practicality Percentage	Category
Classroom Teacher	90%	Sangat Layak

The teacher rated the learning medium’s practicality at 90 percent, which falls in the Very Practical category. This indicates that, from the teacher’s perspective, the medium is easy to prepare and use, manageable in class, and fits the lesson flow. The rating also suggests that content, presentation, language, and contextual alignment were judged favorably.

**Effectiveness**

The pretest and posttest instruments were examined for validity, reliability, difficulty, and discrimination before classroom use. A 30-item multiple-choice pool was piloted with 32 Grade VI students. Item validity analysis retained 22 valid items and rejected 8 items as invalid. Reliability analysis indicated that the 22 retained items were reliable with a very high coefficient, suggesting strong internal consistency. Difficulty analysis showed that the retained items ranged from easy to medium, and discrimination analysis classified them as adequate to good. These checks indicate that the final 22 items were suitable for measuring learning outcomes, though they emphasize descriptive quality rather than inferential claims.

Effectiveness of the Ecowaste learning medium was then examined with Grade V students at SD Negeri 200206 Padangsidempuan using a 20-item multiple-choice test (Minimum Mastery Criterion/Kriteria Ketuntasan Minimal, KKM = 75). Twenty students completed both assessments. The mean pretest score was 58.25, which increased to 86.75 on the posttest, indicating a substantial improvement in performance relative to the KKM threshold. On a descriptive reading, this gain supports the claim that the Ecowaste learning medium contributed to better learning outcomes for the tested cohort. A cautious interpretation is still warranted: while the mean increase is large, distributional details (e.g., proportion meeting KKM, variance, or inferential statistics) were not analyzed here, so the evidence presently shows strong descriptive effectiveness rather than statistical significance.

**Table 5.** Pretest and posttest results

No	Student ID	Value		Post-Pre	Skor Ideal (100)-Pre	N-Gain	% N-Gain
		Pre	Post				
1	H1	35	80	45	65	0.692	69.230
2	H2	45	85	40	55	0.727	72.727
3	H3	55	80	25	45	0.555	55.55
4	H4	70	85	15	30	0.5	50
5	H5	45	90	45	55	0.818	81.818
6	H6	65	90	25	35	0.714	71.428
7	H7	55	85	30	45	0.666	66.666
8	H8	50	90	40	50	0.8	80

No	Student ID	Value		Post-Pre	Skor Ideal (100)-Pre	N-Gain	% N-Gain
		Pre	Post				
9	H9	55	85	30	45	0.666	66.666
10	H10	80	90	10	20	0.5	50
11	H11	65	90	25	35	0.714	71.428
12	H12	40	85	45	60	0.75	75
13	H13	60	85	25	40	0.625	62.5
14	H14	60	90	30	40	0.75	75
15	H15	65	85	20	35	0.571	57.142
16	H16	75	90	15	25	0.6	60
17	H17	60	85	25	40	0.625	62.5
18	H18	70	80	10	30	0.333	33.333
19	H19	45	85	40	55	0.727	72.727
20	H20	70	95	25	30	0.833	83.333
Mean		58.25	86.5	28.25	41.75	0.658	65.852
<b>Criteria</b>		<b>Effective</b>					

The N-Gain analysis indicates an average improvement of 0.658, or 65.85 percent, which meets the effective category for learning outcomes. Mean performance rose from 58.25 on the pretest to 86.50 on the posttest, a mean increase of 28.25 points with individual gains ranging from 10 to 45 points. Mastery relative to the Minimum Mastery Criterion of 75 improved sharply: only 2 of 20 students met or exceeded the threshold before instruction, whereas all 20 students did so after instruction. The distribution of N-Gain percent values spans 33.33 to 83.33 percent, suggesting that most students realized substantial improvement while a few showed modest incremental gains, often due to higher initial scores that leave less room for normalized improvement.

Classifying N-Gain percent using the study’s effectiveness criteria, 3 students reached the Highly Effective band ( $\geq 76$  percent), 13 students fell in the Effective band (56–75 percent), 3 students were in the Less Effective band (41–55 percent), and 1 student was Not Effective ( $\leq 40$  percent). Notably, students with high pretest scores, such as H10 (80 to 90) and H18 (70 to 80), exhibited smaller normalized gains despite improving in absolute terms, reflecting a ceiling effect inherent to the N-Gain metric. Taken together, the shift in mean scores, the universal attainment of mastery, and the predominance of Effective outcomes support the conclusion that the Ecowaste learning medium contributed meaningfully to improved performance on the assessed IPAS content.

### Evaluation Stage

The evaluation stage marks the final phase of the ADDIE model. Drawing on feasibility (expert validation), practicality (teacher and student responses), and effectiveness (pretest–posttest gains), the coconut coir waste-based learning medium–Ecowaste–was reviewed after completion of the Analysis, Design, Development, and Implementation stages. The product met the established criteria: it was rated Highly Feasible, judged Very Practical for classroom use, and demonstrated Effective learning outcomes, indicating readiness for instructional deployment in Grade V IPAS lessons.



**Figure 2.** Coconut coir waste-based learning medium

The findings indicate that the Ecowaste learning medium contributed to improved students' learning outcomes in Grade V IPAS, as reflected by the descriptive N-Gain classified as effective. This pattern is consistent with prior work showing that authentic, material-rich experiences can support process skills and conceptual understanding. For example, using compost as a learning resource improved science process skills among Grade III students (Dewi & Sapri, 2023). The parallel is modest but relevant: both approaches integrate locally available organic materials into classroom tasks to make abstract ideas tangible. A reasonable objection is that the present gains may stem from novelty rather than durable understanding. That concern is partly addressed by our multi-criterion evaluation—feasibility, practicality, and effectiveness—but longer-term follow-up would be needed to confirm retention and transfer.

Evidence from studies on waste-based learning media also aligns with our results. A collage medium developed from recycled waste achieved high ratings for validity (87.5%), practicality (92.5%), and effectiveness (95.27%), suggesting that well-designed, repurposed materials can function as credible instructional tools (Musyrroh, 2015). Our expert validation scores for content and media that rose to highly feasible after revision echo this pattern, although the contexts and subjects differ. The implication is cautious: feasibility and practicality are attainable when design criteria are explicit, tasks are instructional rather than decorative, and teacher orchestration is deliberate. However, the translation from feasibility to consistent learning gains depends on how teachers integrate the medium with questioning, feedback, and assessment routines—factors not exhaustively captured in our study.

The environmental dimension of our design resonates with findings from Adiwiyata school programs, where converting organic waste into learning media is positioned as an innovation to enact environmentally oriented policies at the elementary level (Widiantoro & Misnih, 2023). Ecowaste fits this orientation by modeling 3R practices and situating learning within a local waste stream—coconut coir. Still, we should be careful not to conflate policy compliance with pedagogical impact. Environmental initiatives can become performative if the materials are present but the learning activities remain low in cognitive demand. Our classroom tasks therefore emphasized observation, measurement, and explanation tied to IPAS objectives, rather than mere crafting or display. Even so, the degree to which

students internalize stewardship values likely requires sustained experiences beyond a single unit.

The materials science literature offers a complementary rationale for selecting coconut coir. Coir's lignocellulosic composition—lignin, cellulose, and hemicellulose—underpins mechanical properties that make it usable as a growth medium or component in varied applications (Destyorini et al., 2022; Fernando et al., 2025). Studies in horticultural and agronomic contexts note coir's water retention and aeration characteristics, indicating potential for school experiments on germination or plant growth (Zheng et al., 2024; Gamage et al., 2022). We do not claim that such properties automatically translate into better learning, but they create affordances for hands-on tasks that are otherwise difficult to stage in resource-constrained classrooms. A separate stream of work examines coir in biocomposites, highlighting its versatility for demonstrating concepts of reinforcement, matrices, and sustainability trade-offs in materials education (Nsiah-Gyambibi et al., 2023; Gupta & Ramkumar, 2020). This suggests that a coir-based medium can be leveraged across IPAS topics, from ecological cycles to simple materials science, provided tasks are framed with clear learning goals.

Positioning coir-based activities within broader sustainability education is plausible but should be treated carefully. Initiatives that integrate natural or repurposed materials into lessons are argued to support environmental literacy and foster innovative thinking, especially when students design, test, and reflect on artefacts or processes (Stelte et al., 2022; Mariotti et al., 2020). Classroom use of coir can anchor discussions about ecological cycles, local resource use, and human impacts, potentially bridging school learning with community practices (Nha et al., 2025). The bridge, however, is not automatic. Without structured reflection prompts, criteria for success, and opportunities to generalize from the activity to everyday choices, students may enjoy the task yet miss the conceptual and dispositional targets. Our design incorporated prompts for prediction and explanation, but future iterations could formalize reflection protocols and peer critique to deepen reasoning.

Mechanistically, the improvements observed in this study are consistent with how well-aligned media can reduce cognitive load and enable dual coding. Handling coir-based components externalizes part of the information processing, allowing students to coordinate verbal explanations with tactile and visual cues. This may explain why students who struggled to follow textbook explanations of 3R concepts performed better when asked to classify, manipulate, and discuss concrete exemplars. The contrary view is that any tangible medium would have produced similar gains. That possibility cannot be excluded here, as we did not compare coir-based media to alternative hands-on materials. A practical next step is a comparative design that pits Ecowaste against other low-cost media, holding teacher moves and tasks constant, to discern whether coir's particular affordances matter or whether the effect is primarily "hands-on" generally.

The practicality rating from the teacher (Very Practical) also merits unpacking. Teachers often resist media that are fragile, costly, or time-intensive to prepare. Coir's local availability and low cost likely contributed to favorable judgments, but manageability during class time matters as much. The flow of activities—set-up, use, and clean-up—must fit the lesson's temporal constraints. Our storyboard and

procedural guides aimed to support that fit. Even so, practicality may fluctuate with class size, access to washing or drying space, and storability between lessons. Schools with different constraints might rate the same medium differently, suggesting that future work should document context parameters alongside practicality scores to guide adoption decisions.

The study's descriptive effectiveness should be read with appropriate caution. The N-Gain improvement suggests meaningful progress relative to baseline, and universal attainment of the mastery threshold is encouraging. Yet our data do not adjudicate whether gains persist, transfer to related IPAS topics, or scale to different teachers and schools. Ceiling effects were evident for students with high pretest scores, leading to smaller normalized gains despite absolute improvement; future assessments might include items with a wider difficulty range to reduce ceiling compression. In addition, while our item analysis established validity and high reliability for the selected test items, inferential statistics were not used to estimate uncertainty around mean gains. Incorporating confidence intervals or nonparametric tests in subsequent iterations would strengthen claims.

Two practical implications follow from these findings. First, for schools implementing the Merdeka Curriculum, locally sourced, waste-based media can anchor student-centered lessons without imposing prohibitive costs, provided that teacher guides include clear task sequences and reflection prompts. Second, environmental content benefits from tasks that couple manipulation with explanation; teachers should be supported to facilitate talk that moves beyond naming steps to justifying choices and evaluating outcomes. These implications are modest and actionable. They do not assert that coir-based media are universally superior, only that, under the conditions observed here, such media are feasible, very practical, and associated with effective gains.

Finally, the broader literature on coconut coir in ecological and materials applications offers avenues for curriculum extension. Coir as a nutrient carrier in ecological farming can inform controlled classroom investigations into water retention or growth rates (Zheng et al., 2024). Coir-based biocomposites can anchor simple demonstrations of composite behaviour and sustainable product design (Nsiah-Gyambibi et al., 2023; Gupta & Ramkumar, 2020). These extensions should be piloted with clear rubrics and low-stakes assessments to determine which tasks yield conceptual leverage rather than entertainment. In short, Ecowaste appears to be a credible entry point for IPAS teachers seeking to integrate environmental stewardship with hands-on learning. The present evidence supports cautious optimism, paired with a call for iterative refinement, comparative trials, and follow-up measures to test durability and transfer.

## CONCLUSION

Expert evaluations indicate that the coconut coir waste-based learning medium (Ecowaste) satisfies feasibility requirements for classroom use. The content expert reported 92% and the media expert 91.4%, both classified as Highly Feasible, supporting the claim that the product is valid for instructional deployment. Practicality evidence from the Grade V setting at SD Negeri 200206 Padangsidempuan was also strong: the teacher's rating reached 90% (Very Practical), and student responses averaged 86.35% (Very Good), indicating that the medium is workable to prepare, manage, and integrate into IPAS lessons.

Effectiveness was reflected in measurable learning gains. The mean score increased from 58.25 (pretest) to 86.50 (posttest), yielding an average N-Gain of 0.658 ( $\approx 65.85\%$ ), which falls within the Effective category. These results support the conclusion that Ecowaste contributed to improved learning outcomes for Grade V students on the assessed IPAS content.

Future work should examine retention and transfer across topics, include comparison groups or alternative low-cost media, and report uncertainty estimates alongside mean effects. Documenting context parameters that influence practicality (e.g., class size, facilities, storage) would also enhance guidance for adoption in schools with varying constraints. Consistent reporting of summary values across sections should be ensured during final manuscript preparation.

## RECOMMENDATION

Using learning media can help students grasp content more effectively, so teachers should design and apply media that align with lesson goals and classroom conditions to make instruction clearer, more engaging, and manageable. Teachers are encouraged to innovate in selecting, adapting, and evaluating media, with hands-on practice and reflection built in. Future research should develop classroom media from other creative, waste-based materials and assess their feasibility, practicality, and effectiveness using transparent criteria.

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