



IMPROVING LITERACY AND NUMERACY SKILLS FOR KINDERGARTEN AND ELEMENTARY SCHOOL CHILDREN THROUGH THE UTILIZATION OF RECYCLED WASTE IN PITEWI VILLAGE, KEEROM REGENCY

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Abstract :

This study aims to describe the improvement of literacy and numeracy skills of kindergarten and elementary school children through the use of recycled waste as contextual learning media in Pitewi Village, Keerom Regency, Papua. The study used a descriptive qualitative approach with a case study design. Data were collected through participatory observation, in-depth interviews, and documentation of the learning process, children's involvement, and teacher and community experiences. Learning media were developed from locally available recycled materials, such as bottle caps, cardboard, cans, paper, and old newspapers. The results showed that before the intervention, children's literacy and numeracy skills were generally in the Beginning to Develop (MB) category. After the implementation of recycled media, there was an increase in the achievement of literacy indicators from 35% to 78% in phonological and letter awareness, and from 30% to 85% in word formation and comprehension. In numeracy, the achievement of the indicator for recognizing symbols and quantities increased from 28% to 82%, while for patterns, geometry, and basic operations increased from 25% to 88%. The use of recycled loose parts also increases children's active engagement, curiosity, creativity, and courage in learning. Thus, recycled media has proven to be an affordable, contextual, participatory, and sustainable learning alternative for strengthening children's literacy and numeracy in remote areas of Papua.

Keywords: Literacy, Numeracy, Recycling waste, Loose parts, Early childhood, Papua

INTRODUCTION

Science (IPA) learning in elementary schools holds a very strategic and important position. Students at YPK Ebenhaizer Yamna Elementary School are not simply learning science content for themselves, but rather preparing themselves as the next generation, who will be responsible for building the foundation of scientific literacy at higher levels. Therefore, the quality of science learning in elementary schools has a multi-layered impact on student competency and determines the quality of future generations of students.

Literacy and numeracy skills are the foundation of learning that determine a child's readiness to participate in the educational process at the next level. These skills relate not only to technical reading, writing, and arithmetic skills, but also to a child's capacity to understand information, reason, solve problems, and participate in more complex learning experiences. UNICEF emphasizes that basic



reading and numeracy skills developed in early childhood are building blocks for future learning; even in many low- and middle-income countries, delays in mastering these basic skills remain part of the global learning crisis (UNICEF, 2022). Similarly, Wickstrom and Pyle (2025) demonstrate that teacher-led play-based learning can strengthen children's early mathematical foundations more meaningfully because it aligns with the concrete, active, and contextual learning styles of early childhood.

In the Papuan context, the issue of basic literacy and numeracy is becoming increasingly important due to its intersects with geographic issues, limited educational facilities, linguistic diversity, and unequal access to early childhood education (PAUD) services. UNICEF Indonesia reported that a new phase of the Rural and Remote Education Initiative for Papua Provinces program was launched to improve basic literacy and numeracy for children in Papua because baseline studies in target districts showed that approximately 12% to 69% of third-grade students were still classified as non-readers; this condition is related to limited teacher training, a lack of reading materials, and challenges in the quality of learning services in remote areas (UNICEF, 2024). The findings of Wijaya and Siantoro (2025) also show that improving elementary school student literacy in remote Papuan areas is closely related to access to PAUD/TK and recognition of children's first language. Thus, literacy and numeracy issues in Papua cannot be understood solely as individual student weaknesses, but must be read as structural and pedagogical issues that require contextual solutions.

Keerom Regency, including Pitewi Village, represents a regional context facing limitations in learning media, books, teaching aids, and locally sourced learning support. In such situations, learning that relies too heavily on ready-made media or standard teaching materials is often difficult to implement optimally. In fact, kindergarten and early elementary school children need concrete learning experiences that are close to their environment, can be touched, moved, arranged, compared, and their meaning negotiated through play-learning activities. McLean, Cummings, Mooney, and McIsaac (2026) emphasize that children's literacy and numeracy can emerge organically in play environments when teachers provide open-ended materials, exploratory spaces, and appropriate pedagogical documentation. This means that limited formal facilities do not always have to lead to low-quality learning if educators are able to transform surrounding resources into meaningful media.

One potential but often overlooked environmental resource is recycled waste, such as plastic bottles, cardboard, used paper, bottle caps, cans, and other household waste. From an early childhood pedagogical perspective, these objects can function as loose parts or open materials that provide ample opportunities for children to group, count, arrange patterns, recognize symbols, create stories, name objects, and represent ideas visually and verbally. Cankaya, Rohatyn-Martin, Leach, Taylor, and Bulut (2023) in a literature review in the *Journal of Intelligence* explained that playing with loose parts is related to children's cognitive development, especially problem-solving, reasoning, flexibility of thinking, and creativity. Meanwhile, Chookah, Agbenyega, Santos, and Habak

(2024) showed that both natural and non-natural materials support children's imagination, creativity, and complex thinking in play-based learning tasks. These findings provide a theoretical basis that recycled materials are not just a cheap alternative but can also be a meaningful pedagogical medium.

However, most previous studies have focused on the relationship between loose parts and creativity, general cognitive development, or play-based learning more broadly. Research specifically examining the use of recycled waste as a medium for improving literacy and numeracy in kindergarten and early elementary school children in the context of remote villages in Papua is still very limited. Furthermore, existing studies have generally been conducted in school or government contexts with more established pedagogical support and infrastructure, thus failing to fully explain how recycled materials are interpreted, used, and negotiated by teachers, children, and communities in the 3T (Underdeveloped Region) region. Therefore, a qualitative study is needed that can capture the experiences, practices, local meanings, and social processes behind the use of recycled waste as a contextual learning medium in Pitewi Village, Keerom Regency.

Based on this description, this research is crucial to conduct an in-depth examination of how recycled waste can be utilized as a contextual, affordable, creative, and sustainable learning medium to support the strengthening of literacy and numeracy in kindergarten and elementary school children in Pitewi Village. This study is not only relevant to developing learning practices in remote areas but also has the potential to enrich the discourse on inclusive, environmentally-based basic education that is sensitive to Papua's socio-cultural realities.

RESEARCH METHODS

1. Time and Place of Research

This research will be conducted over four months, from April to July 2026. The research will be located in Pitewi Village, Keerom Regency, Papua Province. Specifically, the research will be conducted in kindergartens (TK) and elementary schools (SD) in Pitewi Village and its surrounding areas that are accessible during the research period.

2. Research methods

This research uses a descriptive qualitative approach. Qualitative methods were chosen because this study aims to gain an in-depth understanding of the process, meaning, and context of utilizing recycled waste in children's literacy and numeracy learning. According to Sugiyono (2022), descriptive qualitative research seeks to describe and analyze social phenomena in depth without experimental intervention.

The research design used was a case study, with Pitewi Village as the single case studied intensively. This case study was chosen because it allowed researchers to holistically examine the phenomenon of recycled media-based learning within a unique and specific real-world context.

3. Research Subjects

The sample determination in this qualitative research used a purposive sampling technique, which involves deliberately selecting participants

based on specific criteria and considerations relevant to the research objectives. The research participants included:

- a. Kindergarten-aged children (4-6 years) in Pitewi Village: 15-20 children
- b. Children in grades I-III of elementary school in Pitewi Village: 20-25 children
- c. Kindergarten teachers: 2-3 people
- d. Elementary school teachers grades I-III: 2-3 people
- e. Principal: 1-2 people
- f. Parents/guardians of children: 5-8 people as supporting informants

4. Method of collecting data

Data in this study were collected through three main methods:

a. Participatory Observation

Researchers will conduct direct observations of children's learning processes in and outside the classroom using media made from recycled waste. Observations will be participatory, meaning researchers will be involved in the learning activities while conducting systematic observations. The focus of observations will include: children's interactions with media, their responses to literacy and numeracy activities, and classroom dynamics.

b. In-depth Interview (In-depth Interview)

In-depth interviews were conducted with teachers, principals, and parents to gather information about their understanding of literacy and numeracy learning, the challenges they face, and their perceptions of the use of recycled media. The interviews used a semi-structured interview guide developed by the researchers.

c. Documentation

Documentation data collected includes: photos and videos of the learning process, children's work from recycled media, teacher field notes, and relevant educational documents such as syllabi, lesson plans, and child development reports.

5. Research Instruments

Table1. Research Instruments

Instrument	Component	Objective
Observation Guidelines	Competency indicators of children's literacy and numeracy abilities	Recording classroom learning practices
Interview Guide	Conceptual understanding, design skills, implementation practice, constraints	Exploring informants' perceptions and experiences
Document Analysis	Suitability of RPP, media relevance, cultural context	Analyzing learning artifacts

Sheet	in the document	
Field Notes	Context, atmosphere, unexpected interactions, researcher reflections	Enriching descriptive data

6. Data Analysis Techniques

Data analysis used the interactive model of Miles, Huberman, and Saldana (2014) which consists of four components that occur simultaneously and iteratively:

- Data Condensation: The process of selecting, centralizing, simplifying, and transforming raw data through coding using open coding, axial coding, and selective coding approaches.
- Data Display: Condensed data is presented in the form of descriptive narratives, matrices, and conceptual diagrams to facilitate drawing conclusions.
- Conclusion Drawing and Verification: Conclusions are drawn inductively and continuously verified against new field data.

7. Research Procedures

The research was carried out through three procedural stages as follows:

Stage I: Preparation

- Preparation and validation of research instruments
- Processing research permits to the Keerom Regency Education Office
- Coordination with the principal and teachers at the research location
- Preliminary study to map initial conditions
- Collection of recycled materials and preparation of learning media

Phase II: Implementation

- Observation of the initial learning process (baseline)
- Workshop for teachers on making media from recycled waste
- Assistance in the implementation of literacy and numeracy learning based on recycled media
- Data collection through observation, interviews and documentation on an ongoing basis
- Ongoing data analysis during the research process

Stage III: Closing

- Thorough data analysis
- Preparation of research reports
- Research results seminar with local stakeholders
- Preparation of scientific articles for national journal publication
- Submission of final report to the institution and the Department of Education

RESULTS AND DISCUSSION

1. Initial Conditions (Baseline)

In the early stages before intervention, the average basic literacy and numeracy skills of children were at the MB (Beginning to Develop) level or not yet developed. Children have difficulty recognizing letter-sound relationships and the concept of quantity numbers above 10 because previous teachers' teaching methods tended to be dominant in drills and lectures without manipulative media.

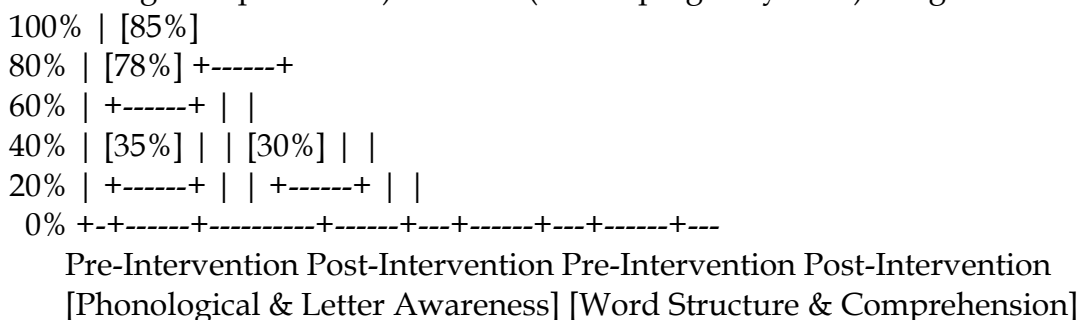
2. Process of Utilizing Recycled Waste

Learning is designed using recycled media collected together with the village community:

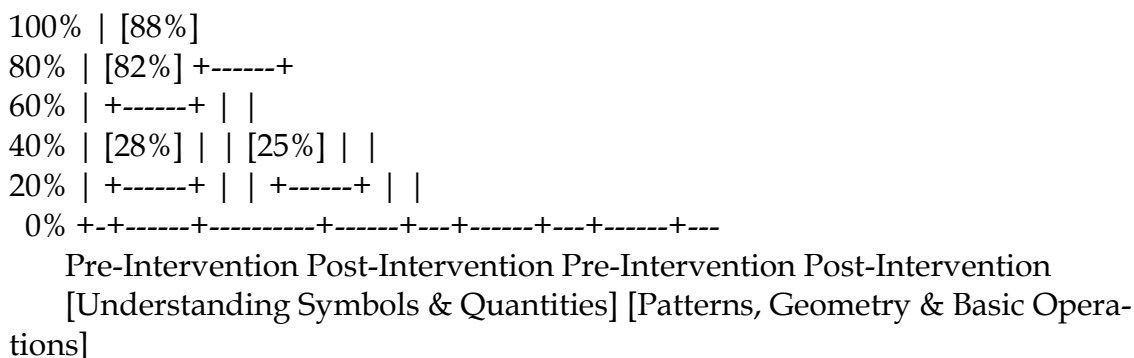
- Colorful Bottle Caps: Used for counting, color patterns, and simple addition/subtraction operations.
- Used Cardboard & Cans: Formed into letter cards, number puzzles, and building blocks for geometric shape recognition and word formation.
- Waste Paper & Newspaper: Used in squeezing activities, forming letter symbols, and making simple picture story books.

3. Increasing Literacy and Numeracy Skills

Based on the development indicator observation sheet, there was a significant increase in the percentage of children achieving the BSH (Developing According to Expectations) and BSB (Developing Very Well) categories.



Picture1 Percentage of Achievement of Children's Literacy Indicators (Kindergarten & Early Elementary School)



Picture2 Percentage of Achievement of Children's Numeracy Indicators

(Kindergarten & Early Elementary School)

The results of observations of developmental indicators for kindergarten and early elementary school children showed a significant increase in the categories Developing According to Expectations (BSH) and Developing Very Well (BSB) after the learning intervention was carried out. This increase in literacy and numeracy skills is clearly visible from the comparison of achievements between the pre-intervention and post-intervention stages in Graph 1 and Graph 2.

In the literacy indicator (Chart 1), the Phonological & Letter Awareness sub-indicator experienced a significant jump of 43%, from only 35% pre-intervention to 78% post-intervention. A much higher jump occurred in the Word Formation & Comprehension sub-indicator, namely 55%, increasing from 30% pre-intervention to 85% post-intervention. This indicates that the use of concrete learning media is very effective in helping children understand the relationship between letters and sounds and construct meaningful words.

Meanwhile, improvements in the numeracy indicators (Chart 2) also showed consistent results. In the Recognizing Symbols & Quantity sub-indicator, children's achievement increased by 54%, moving from 28% in the pre-intervention phase to 82% after the intervention. Meanwhile, the Patterns, Geometry & Basic Operations sub-indicator recorded the largest increase, reaching 63%, from an initial achievement of 25% to 88% in the post-intervention phase.

Overall, the data from both graphs shows that children's abilities were still relatively low in the pre-intervention phase, with all indicators falling within the 25%–35% range. However, the recycled-materials-based learning media intervention was shown to boost children's achievement, reaching 78%–88% in the post-intervention phase.

This drastic improvement confirms that a manipulative approach using concrete media can bridge children's understanding from abstract concepts to concrete meanings. Therefore, the implementation of this intervention has been shown to have a significant positive impact on accelerating children's basic literacy and numeracy skills in early childhood education and elementary school.

These findings align with research by Wickstrom & Pyle (2025) and McLean et al. (2026), which confirmed that the use of concrete materials that can be manipulated exploratively accelerates children's mastery of abstract symbols. The use of loose parts made from recycled materials has been shown to increase student engagement and reduce learning anxiety.

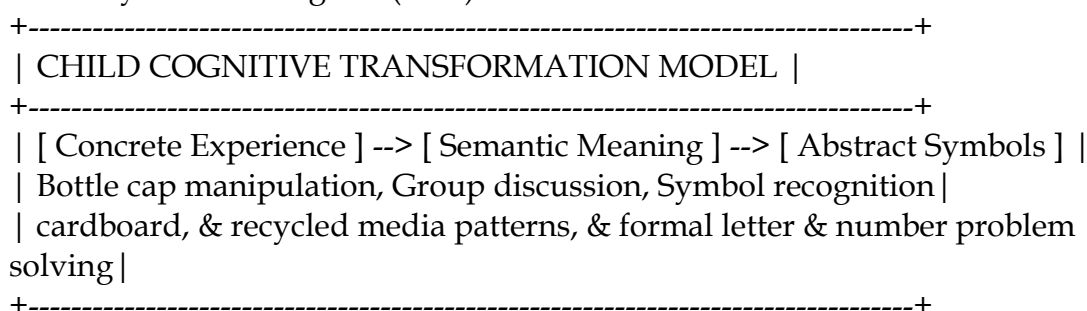
3.1 Conceptual Transformation from Concrete Objects to Abstract Symbols Through Recycled Loose Parts

Field findings in Pitewi Village indicate that the use of recycled waste – such as plastic bottle caps, cardboard pieces, used cans, and newspaper – significantly accelerates the understanding of kindergarten and early elementary school children from the concrete thinking stage to mastery of abstract symbols in literacy and numeracy. These results align with the findings of Wickstrom and

Pyle (2025) who emphasized that early mathematics and literacy learning in children develops most optimally when placed within the continuum of guided play, where the concrete materials manipulated by children serve as cognitive scaffolds. Children aged 4–9 years in remote areas of Papua often experience learning obstacles not because of limited intellectual capacity, but because of the imposition of premature abstraction through printed worksheets or memorization methods without supporting media.

When children in Pitewi Village interact with colorful bottle caps to group quantities or arrange letters into words, they are not simply memorizing visual symbols. They are engaged in a multisensory meaning-making process. This finding is supported by McLean et al. (2026), who emphasized that pedagogical documentation and the availability of open-ended materials in children's education programs make literacy and numeracy learning visible and actively negotiated by children. Recycled materials provide flexible affordances; bottle caps can represent a single number, become vowels, or be arranged in a linear pattern. This material flexibility allows children to represent their ideas without fear of error, thus gradually building phonological understanding and quantity awareness naturally.

From the perspective of cognitive and socio-cultural constructivism theory, this recycling-based manipulation of real objects facilitates the internalization of concepts. Purpura et al. (2024) and Clements et al. (2023) revealed that early indicators of numeracy success—such as number relations and basic number operations—depend heavily on how often children are exposed to concrete representations of the cardinality of numbers. When a child in Pitewi Village counts 10 bottle caps and transfers them to a used cardboard box, the concept of "ten" is understood as a combination of real units, not just the meaningless symbol "10." The same thing happens in literacy: forming letters from rolled-up newspaper or matching letter cards from pieces of used cardboard helps children map the visual form of letters (orthographic mapping) with the sounds of their language (phonological awareness), as also explained by Cadime et al. (2025) and Kennedy and McLoughlin (2023).



3.2 Increasing Student Engagement and Reducing Math & Reading Anxiety

One of the most striking findings from classroom participant observation was a dramatic shift in the children's affective dynamics. Before the recycled media intervention, children tended to be passive, hesitant, and some showed signs of anxiety when asked to read in front of the class or solve math problems

on the board. Conventional paper-and-pencil-based learning created a stressful, evaluative atmosphere for young children in the 3T (third-third) region. However, the presence of recycled waste packaged in a group game format drastically reduced the children's affective filter (emotional barrier).

This increase in student engagement aligns with research by Cankaya et al. (2023), which found that loose parts play is closely linked to strengthening executive function, self-regulation, and increased attention span in preschool and early grade children. Because recycled materials don't have a single, rigid set of rules like manufactured toys or formal textbooks, children feel a sense of agency over their learning process. This sense of ownership fuels intrinsic motivation. Children in Pitewi Village voluntarily try to construct new words or create more complex number patterns with their peers.

In addition to increasing engagement, the use of recycled media has been shown to significantly reduce learning anxiety, particularly in numeracy (math anxiety). Gashaj et al. (2023) studied how the absence of math anxiety in early childhood development is a key predictor of future academic achievement in mathematics. Recycled waste eliminates the perception that mathematics and reading are daunting evaluative burdens. If a child's stack of bottle caps or cardboard falls over or miscalculates, they don't perceive it as an academic failure, but rather as part of a playful exploration that can be corrected. The friendly, non-threatening nature of the media, familiar to their everyday environment, creates a psychologically safe learning environment.

3.3 Pedagogical Advantages of Recycled Materials Compared to Manufactured Media

Theoretically and practically, recycled learning media in Pitewi Village should not be viewed as an "emergency option" or "merely a cheap alternative" due to a lack of facilities. Instead, this media has intrinsic pedagogical advantages that factory-made educational toys often lack. Chookah et al. (2024) in their study on play affordances compared natural and non-natural materials (including used/recycled materials) and concluded that recycled non-natural materials offer a very rich flexibility of shape, color, and texture to stimulate imagination, creativity, and complex thinking.

Factory-made toys are generally closed-ended (having a single, fixed function, such as plastic puzzles that can only be assembled one way). In contrast, used milk cartons in Pitewi Village can be cut into letter cards, folded into number dice, or stacked into geometric towers. The implication is that children's cognitive capacities are challenged to continually project new meaning onto the same objects. Research by MacDonald et al. (2023) and O'Rear et al. (2023) shows that the use of varied and contextualized manipulatives directly strengthens children's spatial reasoning, number compositional abilities, and intuitive problem-solving.

Table2. Summary of pedagogical comparison between conventional/manufactured instructional media and recycled waste loose parts media applied in this study

Evaluation Dimensions	Conventional Media / Printed Text	Factory Plastic Toys	Recycled Media (Loose Parts)
Characteristics of Nature	Passive, abstract, two-dimensional	<i>Closed-ended</i> , rigid structure	<i>Open-ended</i> , very flexible
Accessibility	Limited to remote areas/3T	Expensive, hard to renew if damaged	Abundant, free, environmentally friendly
Children's Emotional Responses	Potentially anxiety-inducing	Interesting but quickly triggers boredom	Encourage curiosity & imagination
Environmental Context	Separated from local reality	Separated from local context	Contextual, instilling ecological ethics
Cognitive Development	Declarative/rote memory	Isolated motor skills	Executive functions & problem solving

3.4 Sustainability Education and Socio-Cultural Integration of Papua

The utilization of recycled waste in Pitewi Village touches on a broader pedagogical dimension, namely Education for Sustainable Development (ESD). As demonstrated by Sihvonen et al. (2024) and Buil et al. (2019), facilitating the habituation of recycling and waste reuse from an early age fosters long-term ecological awareness and environmental concern. Children in Pitewi Village not only learn to recognize the letter "B" or count from 1 to 20, but are also indirectly accustomed to seeing that the waste around their village has value and can be transformed into something useful.

In the context of Papua, this approach is very relevant to efforts to overcome the basic literacy crisis without tearing children away from their

roots.culture. Wijaya and Siantoro (2025) and a report by UNICEF Indonesia (2024) emphasized that literacy interventions in Papua will fail if they are forced to use external curricula or media that are unfamiliar to children's daily lives. By involving local household and recycled materials, the learning process becomes culturally responsive pedagogy. Children integrate their native language when interacting with recycled media, transition naturally to Indonesian, and work together to collect recycled materials with their parents and village community.

4. Supporting and Inhibiting Factors

The implementation of the use of recycled waste as a medium for increasing literacy and numeracy in Pitewi Village, Keerom Regency, cannot be separated from the dynamics of driving factors that facilitate activities as well as constraints that require adaptive solutions.

4.1 Supporting Factors (Enabling Factors)

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	MAIN SUPPORTING FACTORS
+-----+	
	1. Abundance of local recycled waste (bottle caps, cardboard, cans)
	2. Enthusiasm & active participation of the children of Pitewi Village
	3. Collaborative support from Principals, Teachers, & Local Community Leaders
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1. Abundant Availability of Local Recycled Materials:

Pitewi Village has an abundant supply of inorganic household waste (such as used plastic beverage bottles, bottle caps, cardboard packaging, and cans), but it has not been properly managed. This unlimited supply of materials ensures that each child has access to sufficient manipulative materials without having to strictly share (a zero-cost resource). The availability of readily available local materials ensures the program's sustainability even after the research period concludes.

2. High Enthusiasm and Positive Responses from Children:

Kindergarten and early elementary school children in Pitewi Village demonstrated a high level of enthusiasm and curiosity toward recycled media. The tactile nature of the media (which can be touched, changed, and arranged) aligns with the motor and cognitive developmental characteristics of early childhood. This active engagement led to more consistent school attendance throughout the study period.

3. Strong Support from Local Stakeholders (Community Support):

The principal, teachers, parents, and community leaders in Pitewi Village responded very openly and supportively. Parents actively helped collect used bottles and cardboard from households and nearby stalls to bring to the school. This collaboration creates a community-based educational ecosystem where children's education is a shared responsibility between the school and the village.

4.2 Constraining Factors and Mitigation Strategies

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| MAIN INHIBITING FACTORS |

+-----+

| 1. Initial limitations of teacher capacity in hygienic media design |

| 2. Limited storage facilities & tropical weather factors |

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1. Limitations of Teachers' Initial Skills in Designing Hygienic and Safe Media:

Most teachers at the research site had never received specific training on the concept of loose parts or techniques for processing recycled waste into safe and hygienic learning materials. Initially, there were concerns about the cleanliness of the materials (sharp can edges or dirty bottles).

Mitigation Strategy: The research team conducted intensive workshops and provided assistance with media co-designing. Researchers established standard operating procedures (SOPs) for cleaning materials: cutting off sharp edges, washing with disinfectant soap, and drying before recycled materials are used in the classroom.

2. Storage Space Limitations and Tropical Weather Influences:

School buildings in Pitewi Village have limited cabinets and storage space that are free from moisture. Media made from cardboard or used newspapers are susceptible to damage from rain or damp conditions. Furthermore, insects and termites pose a threat to the media's durability.

Mitigation Strategy: Researchers and teachers designed a modular storage system using thick plastic sacks and used, branded, sealed containers (container boxes) that were hung or placed in a dry area. Furthermore, they instilled the understanding that if the cardboard media were damaged, the children and teachers could easily and cost-effectively recreate them.

CONCLUSION

The use of recycled waste as a concrete learning medium has proven highly effective in improving the literacy and numeracy skills of kindergarten and elementary school children in Pitewi Village, Keerom Regency. This affordable and sustainable medium successfully transformed the learning approach from passive to participatory, exploratory, and meaningful. The use of recycled loose parts democratizes access to quality teaching aids without relying on expensive physical budgets.

Thank-You Note

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