PPD
p-ISSN: 2406-8012 | e-ISSN: 2503-3530
PROFESI PENDIDIKAN DASAR

Enhancing Environmental Awareness and Scientific Behaviour through Buried Compost Bin Media

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Submitted: 2025-01-22
Revised: 2025-03-28
Accepted: 2025-04-28
DOI: 10.23917/ppd.v12i1.9807

Keywords:

mindfulness engineering; buried compost bin; scientific behavior

Abstract

The educational system faces an epistemological dilemma stemming from individuals' limited ability to manage their own waste. The integration of the Pancasila Student Profile Strengthening Project into primary school curricula through the use of Buried Compost Bin (BCB) media is supported by both the notion of human superiority and these challenges. The project followed the ADDIE model, encompassing analysis, design, development, implementation, and evaluation. Tools employed included media validation sheets, student pre- and post-tests, and teacher surveys. A group of 100 students and six teachers was selected to foster environmental awareness and scientific behavioural responses. The BCB media was validated as implementable, accessible, adaptable to various social contexts, and compliant with environmental standards. Statistical methods, including t-tests, were used to analyse quantitative data from teacher evaluations and test results. The findings indicated that BCB media significantly increased awareness and promoted behavioural change, with improvement rising from 12% to 48%. Qualitative linguistic analysis further confirmed a causal link between student media engagement and behavioural change. Overall, BCB media proved effective and efficient in enhancing students' environmental awareness and encouraging scientific behavioural change.

INTRODUCTION

Background of the Study

The limited capacity of human resources to manage natural resources effectively is starkly highlighted by the inadequate state of waste management systems at the individual level (Salvia et al., 2021). Such management skills are not innate; rather, they must be deliberately nurtured. Elima

Israilova's research underscores how the complexities of modern life—including the evolving dynamics of human behavior—create opportunities to cultivate environmental awareness, which serves as a catalyst for behavioral change (Israilova et al., 2023). Human attitudes and actions toward waste are undeniably shaped by the knowledge individuals acquire about the environment and natural resources (Abdel-Shafy & Mansour, 2018). Moreover, insufficient exposure to effective waste management practices—often exemplified by flawed governmental frameworks—is closely tied to society's generally low regard for waste and refuse. This correlation is supported by findings from a survey in Ogun State (Olukanni et al., 2020), which further suggests that repeated exposure to information leads to its deep internalization within the subconscious (Sword-Daniels et al., 2018).

Developing effective waste management behaviors requires a cognitive framework rooted in accurate and comprehensive understanding of environmental and resource-related issues. Once established, this framework becomes deeply ingrained in an individual's mindset, directly influencing their interactions with environmental systems. The internalization of environmental values plays a pivotal role in this process, with media serving as a pedagogical tool to enhance experiential learning and reinforce sustainable tendencies (Fang et al., 2022). As Schuman-Olivier et al. (2020) note, such internalization represents a critical phase in shaping an individual's cognitive perspective on specific topics. Creating a lasting educational impact demands consistent and purposeful engagement with the learning process (Darling-Hammond et al., 2020). Through targeted teaching and learning activities, educators can instill habits that build a robust cognitive foundation for responsible environmental behavior. Ultimately, education emerges as a transformative force, cultivating ethical dispositions vital for sustaining human society over the long term.

The sustainable management of natural resources through transformative shifts in individual perspectives—cultivating not only environmental awareness but also a nuanced understanding of broader ecological systems—requires a strategically embedded approach within primary education. This is because learning activities at this foundational stage engage both empirical, tangible materials that facilitate hands-on experiential learning and abstract, conceptual frameworks that stimulate higher-order cognitive development. Primary school students, who predominantly fall within Piaget's concrete operational stage of cognitive development, represent a formative cohort uniquely receptive to internalising pro-environmental behaviours and embedding sustainable practices (Börnert-Ringleb & Wilbert, 2018; Sutisno, 2024).

Crucially, effective environmental education at this level demands the integration of carefully designed instructional tools (Tharasawatpipat et al., 2025). These resources function as pedagogical scaffolds, enabling children to interact directly with classifications of natural resource components—for instance, distinguishing organic from inorganic materials or biotic from abiotic elements. Such strategies aim to establish clear causal relationships that enhance pupils' comprehension of environmental constituents, which are intrinsically tied to the dynamics of natural resource systems. Strengthening the epistemological underpinnings of these educational practices will not only refine learners' conceptual clarity regarding natural resources but also foster robust environmental consciousness. Ultimately, the capacity of human capital to manage natural resources sustainably hinges upon individuals' foundational worldview of these systems. By embedding such perspectives within early educational paradigms, society can nurture generations equipped with both the cognitive frameworks and ethical dispositions necessary for responsible environmental stewardship.

Problem of The Study

Effective waste and refuse management remains conspicuously absent from mainstream public consciousness, resulting in limited active engagement (Njoku et al., 2025). Communities are often discouraged from addressing these challenges due to persistent perceptions of waste as a driver of social conflict, flooding, and environmental degradation (Ter Ellen et al., 2025). Human interactions with natural resources (SDA) remain predominantly extractive, prioritising utilitarian consumption over holistic

stewardship (McGinnis, 2025). Observational data from prior studies further reveal that post-consumption waste management is rarely integrated into everyday human-environment interactions—such as eating, drinking, playing, cooking, and studying. Consequently, the responsible disposal of biotic and abiotic materials is seldom aligned with the benefits derived from their use.

The systemic failure to manage natural resources sustainably post-utilisation is starkly illustrated by Indonesia's 2024 National Waste Management Information System (SIPSN) report, which highlights that 32.93% of generated waste remains unaddressed. To mitigate this deficit, early education frameworks must incorporate practical, scalable tools capable of fostering sustainable practices. One such solution is the Buried Compost Bin (BCB), an underground composting system designed to decentralise organic waste processing at the household or institutional level. By integrating BCB technology into primary school curricula, students gain hands-on experience in segregating and transforming organic waste into nutrient-rich compost. This approach not only reduces reliance on landfill systems but also cultivates foundational principles of circular resource management from an early age.

Research's State of the Art

McGinnis's research reframes human environmental consciousness as a strategic approach to mitigate the escalating impacts of climate change and reduce risks associated with environmental degradation. They argue that this effort is vital for ensuring human survival across present and future generations. Meeting this challenge demands a coordinated shift toward investment and innovation, positioning environmental awareness as a critical response to trends that increasingly threaten humanity's long-term prospects. Kramer McGinnis's warns that inaction risks catastrophic consequences for human civilization (Kramer McGinnis, 2025). Ainin advocates embedding ecological concerns within primary school curricula to foster environmental consciousness. Grounded in foundational education principles, this approach emphasizes learning media as a prerequisite for effective instruction. These tools are essential for enabling young learners to engage meaningfully with educational content (Colineaux et al., 2025). The scientific learning method, which prioritizes process-oriented inquiry, critical thinking, and diligence, is particularly effective in this context (Huang et al., 2025).

This educational framework supports broader efforts to shape human behavior through structured cognitive development. Building critical thinking skills involves a systematic process of intellectual habituation, beginning with observation and progressing through comparison, classification, organization, and evidence-based conclusions (Cerchione et al., 2025). In its final stage, this approach engages students in practical decision-making, such as sorting waste by type, using learning media aligned with established educational standards. This method is consistent with the pedagogical principles of primary education. Furthermore, fostering responsibility for personal waste management—particularly distinguishing between biotic and abiotic components after use—reflects a value-driven outcome rooted in rigorous knowledge-building processes.

Three fundamental elements support the evolution of BCB as a learning resource that fosters sustainable development, as indicated by prior research: The challenge of waste management in Indonesia has shown consistently minimal progress in percentage terms over time. Data from the National Waste Management Information System (SIPSN) reveal that roughly 35–40% of total waste generation remains unregulated annually. An examination of eight consecutive years of data indicates variations in waste generation, with a lack of consistent decrease in the percentage of unmanaged waste in almost every year. This highlights an immediate necessity for innovative waste management solutions that address the source directly. There is an urgent need to create a waste bin media model to enhance environmental awareness among individuals, thereby encouraging responsible waste management of their own refuse. The relevant data mentioned above are presented in Table 1 and Figure 1 below.

Table 1. Annual Waste Production and Unmanaged Waste Proportion in Indonesia (2018–2025)

Year	Total Waste Collected (Million Tonnes)	Proportion of Unmanaged Waste (%)
2018	32.000.000	35.67%
2019	20.900.000	34.29%
2020	31.900.000	35,.67%
2021	67.800.000	31%
2022	22.450.000	37.51%
2023	32.010.000	35.80%
2024	31.009.000	31.90%
2025	33.620.000	39.91%

Figure 1. Graph of Unmanaged Waste Quantities

The second aspect pertains to the deficiency of public awareness and engagement in tackling personal waste management issues. To examine this, the researcher utilised a survey methodology, independently evaluating interest and responses from 200 randomly chosen participants. The sample consisted of 100 males and 100 females, aged 15 to 55 years, with varied occupational and educational backgrounds. The findings indicated that seven informants, comprising both males and females, confessed to habitually disposing of waste in multiple urban areas while recognising the inappropriateness of their behaviour. These individuals indicated a willingness to adopt improved waste management practices if feasible alternatives were accessible. Nevertheless, the remaining 193 informants exhibited significantly low interest and initiative in pursuing solutions for their waste. Thus, the data indicate that fewer than one in ten individuals who improperly dispose of waste demonstrate any willingness to rectify the situation.

The third aspect emphasises the media's role in promoting environmental sustainability. The researcher administered a survey to assess this aspect, observing that although waste bins designated for specific waste types are prevalent in numerous public and semi-public areas, their efficacy is inconsistent. Semi-public spaces, including Adiwiyata schools and formal educational institution offices, are characterised by a relatively uniform demographic of waste bin users. Conversely, entirely public spaces, including hospitals, cafeterias, and thoroughfares, exhibit significant diversity among user demographics. The survey results reveal that waste in these bins frequently remains unsorted, with organic and inorganic materials

mixed together. This observation underscores the necessity for innovative waste bin designs that are both efficient in promoting proper waste sorting during use and economical in implementation. The researcher has proposed improvements to current waste bin designs to enhance functionality, decrease costs, and promote greater environmental awareness and behavioural change.

Gap Study & Objective

The cultivation of responsible attitudes towards the utilisation of natural resources constitutes a core axiological dimension of education and a commendable disposition that warrants robust promotion (Law et al., 2025). The process by which knowledge is constructed and shapes an individual's behaviour represents an epistemological facet of education. Education that advances sustainable development prioritises the processes through which learners access, comprehend, analyse, and apply information, both directly and indirectly. UNESCO emphasises the importance of behavioural responses to threats to planetary balance, advocating educational programmes that foster knowledgeable, skilled, and value-oriented individuals whose attitudes and behaviours promote environmental, economic, and social well-being (Jangir et al., 2025). Consequently, education must nurture the ability to evaluate and adopt optimal behaviours. Furthermore, embracing responsibility for securing a better future for all stakeholders is pivotal in shaping the world's trajectory. Akinsemolu's research highlights the role of green education in driving social and behavioural change, positioning it as a critical determinant of whether education achieves its aims as an instrument of sustainable development (Murray et al., 2025).

Recognising the critical role of education in fostering sustainable development, education should not focus solely on outcomes. Rather, it should constitute a process that cultivates critical thinking and practical competencies. The epistemology of education guides the refinement of stages in developing an accurate perspective on a given issue, which subsequently informs decision-making and behaviour. Sweeting, (2024) underscore the importance of mechanisms underlying behaviour and their motivating factors, arguing that overcoming barriers to responsible behaviour is a principle that education can effectively harness. This view highlights the potential of knowledge acquisition processes to enhance the quality of human behaviour (Rigon, 2025).Działek et al.,(2025) and Shen (2023) contend that learning serves as the foundational stage in cultivating knowledge, which in turn shapes the quality of an individual's behaviour.

The processes of decision-making and behaviour formation rest on complementary pillars, within which media play a significant role. Learning media, as essential educational resources, facilitate the transmission of information by rendering it in accessible formats. Media are instrumental in shaping an individual's worldview and understanding of a subject. By enhancing the perceptual process, media elicit responses that influence attitudes and behaviours (Zhang et al., 2023), affirms that learning media contribute to effective and efficient educational processes.

The literature review highlights the importance of education grounded in epistemological principles, which guide knowledge acquisition and enhance decision-making through informed perspectives, ultimately fostering attitudes and behaviours that ensure environmental balance and sustainability. This study aims to develop BCB media as a learning resource designed to strengthen human environmental consciousness and promote scientifically informed behaviours. As an epistemological tool within education, BCB media embody axiological principles, fostering responsible environmental stewardship.

METHOD

This study employs a developmental research approach guided by the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), utilising a mixed-methods framework that integrates qualitative and quantitative methodologies. The experimental and correlational design is

well-suited to examining cause-and-effect relationships. Conducted at Muhammadiyah III Primary School in Cirebon, the study involved a sample of 100 students and six teachers. The research was integrated with the phases of the Pancasila Student Profile Strengthening Project (P5) within the primary school context, emphasising the cultivation of habitual practices and the establishment of a sustainable school culture. The ADDIE process encompassed analysis, design, development, implementation, and follow-up evaluation.

Design of Research

The BCB medium, developed as an educational resource, is designed to bolster students' environmental consciousness. It was integrated into the school setting through the phases of analysis, design, development, implementation, and follow-up evaluation. The medium was embedded within the Environmental and Natural Resources (SDA) module, aligned with the Sustainable Lifestyles theme. Additional resources included a P5 module, structured across the stages of introduction, contextualisation, action, reflection, and follow-up, to promote habitual practices and embed a sustainable culture within the school. Additionally, BCB was incorporated into the curriculum under the theme of Sustainable Lifestyles, specifically within the Environmental and Natural Resources (SDA) module. Supplementary materials included a P5 module aligned with the sustainable lifestyle theme, structured across the stages of introduction, contextualisation, action, reflection, and follow-up to promote habitual and cultural integration within the school.

Data and Data Sources

The study's quantitative data , emphasizing participants' responses to awareness and behavioral outcomes associated with the BCB media intervention, were collected from 100 student participants and 6 teacher participants . Qualitative data were derived from teacher questionnaires and student test results, which served as supplementary sources for in-depth analysis. A linguistic approach was employed to examine the qualitative data, aiming to explore the underlying meanings of each question item and aspect. To investigate how participants conceptualized and articulated environmental awareness, the analysis centered on causal relationships within their responses.

Data Collection Technique

Multiple instruments were utilised for data collection in this study. To evaluate students' environmental perceptions, awareness, and behavioural patterns, a pre- and post-test design was employed. The test comprised 14 items: seven items addressed awareness within the affirmation domain, and seven pertained to scientific behaviour within the confirmation domain. Additionally, a teacher questionnaire was utilised to collect supplementary data, facilitating an examination of students' perceptions and behaviours as influenced by the enhancement of their environmental awareness (SeeTable 2).

Table 2. Test Instrument

Aspect of Question	Number of Item(s)
Awareness as Affirmation	7
Scientific Behavior as Confirmation	7 questions
Total	14 questions

Data collection was conducted using pre- and post-intervention tests administered to students before and after the treatment, as well as teacher questionnaires to assess students' perceptual and behavioral outcomes. The instruments were designed to measure two key domains: student perceptions as affirmation

data (reflecting awareness) and behavioral data as confirmation (demonstrating changes in actions). Student and teacher responses were quantitatively analyzed in percentages to determine the extent to which behavioral changes aligned with heightened awareness. Perceptual data were derived from the average scores of pretest and posttest results, while teacher perceptions were statistically analyzed using techniques such as t-tests to identify the significant impact of the BCB media integrated into project-based learning programs aimed at fostering behavioral change through increased awareness. To explore causal relationships between the strategies employed by students and shifts in their awareness and subsequent behavior, the researchers conducted qualitative linguistic analysis. This method examined how students' actions were influenced by their evolving consciousness. Through this comprehensive data collection approach, the study ensured the validity of the instruments, the effectiveness and efficiency of the BCB media, and its capacity to cultivate environmental awareness among students (See Table 3).

Table 3. Data Types and Collection Techniques

Data Type	Instrument	Data Collecting Technique
Student Responses	Pre- and Post-Test Sheet	Testing, Scoring, Percentage Calculation
Teacher Responses	Questionnaire Sheet	Expert Review/Evaluation
Cause-and-Effect Analysis	Student Test Results and Teacher Questionnaire	Linguistic Analysis

Data Analysis

This mixed-methods study employs both qualitative and quantitative approaches. Data collection commenced with a quantitative approach, utilising statistical analysis to process data derived from instruments designed to capture quantitative aspects. Following statistical analysis, the findings were interpreted to derive deeper insights. Quantitative results are presented in graphical form, while interpreted data are organised in tables and described in narrative paragraphs, constituting the study's findings.

RESULTS

Analysis

The BCB medium, developed as a tool for household waste management, was conceptualised based on several underpinning factors. Firstly, there is an absence of a communal profile for domestic organic waste processing media, as noted by Maryanti (2017) and Farahdiba et al. (2023). Such a medium not only mitigates the spread of waste in the environment but also has the potential to improve the behaviour of individuals, who are the primary producers of waste. The design of the waste bin medium accounts for environmental chemistry, addressing the biotic risks posed by household waste, which can contaminate soil, water, and air. Secondly, there is a lack of simple, practical, effective, and cost-efficient waste processing mechanisms, as highlighted by Abdel-Shafy and Mansour (2018).

The researchers underscore the critical importance of improving human behaviour towards the waste individuals generate. Behaviour, as a product of cognition, stems from the accumulation of knowledge and insights, which determine whether an individual prioritises or disregards a given issue. This process resides within the realm of deep learning, where the perceived significance of an issue hinges on the accurate dissemination of knowledge. Consequently, behaviour is directly proportional

to one's perception of a subject. The capacity to adopt optimal behaviours following the utilisation of resources falls within the axiological domain of education, necessitating an epistemological foundation—namely, the process through which knowledge is internalised by an individual.

Observational findings reveal a pattern of habitual behaviours among most students, whose daily activities—such as playing, eating, drinking, and studying—frequently result in environmental harm. These activities, often involving the use of natural resources, are rarely followed by responsible waste management practices. This reflects a deficiency in the axiological and practical outcomes of education, as the value and benefits of educational processes are not yet evident in students' behaviours. The interplay between the value and utility of a product is inseparable from its underlying processes. These findings provide the rationale for designing the proposed product.

Design

Individuals are capable of managing waste effectively at the household level. To support such efforts, the researchers developed the BCB (Biopore-Integrated Composting Burial) medium as an innovative tool. The BCB medium draws upon three established waste processing methods: biopore infiltration pits, bioconversion, and principles derived from Islamic burial systems. In addition to its environmental benefits, the BCB medium has the potential to influence behaviour by raising awareness of the importance of environmental conservation and responsible natural resource management. It was specifically designed to address persistent waste management challenges that remain inadequately addressed by conventional approaches.

The BCB model integrates principles from both Science and Technology (Ilmu Pengetahuan dan Teknologi, IPTEK) and Faith and Piety (Iman dan Taqwa, IMTAK), thereby adopting a holistic approach that bridges scientific understanding with ethical values. This integration enables the BCB medium not only to function as a tool for sustainable development through experiential, waste-based learning but also to promote a zero-waste philosophy that emphasises the productive reuse of organic materials. The system enhances the functionality of traditional absorption pits through the application of biopore technology, which significantly reduces the risk of environmental contamination caused by leachate—a hazardous byproduct of decomposing waste.

By addressing both solid waste and leachate at their source, the BCB innovation minimises waste accumulation while fostering environmental awareness at the household level. In particular, it encourages science-informed behavioural change among students, contributing to the cultivation of more sustainable habits and a heightened sense of environmental responsibility.

Development

The design process progressed to the validation stage, during which the researchers prepared the BCB medium for assessment by presenting it in the form of an instrument sheet ready for expert evaluation. This phase aimed to examine the effectiveness and efficiency of the BCB medium with respect to fundamental scientific principles. Validation was conducted by two experts in urban waste processing technology: Dr Ucik Ika Fenti Styana, S.Si., M.Eng., and Muhammad Sigit Cahyono, ST., M.Eng. The resulting BCB prototype functions not only as a medium for waste management but also as a tool that promotes environmental sustainability, serves as an educational resource, and, most importantly, contributes meaningfully to the goals of sustainable development.

Table 4: Evaluation Aspects and Scores for BCB Media

No.	Evaluated Aspect	Score			
		1	2	3	4
A.	**Efficiency Aspects**				
1	Clarity of the media's workflow				√
2	Ease of use and operation				√
3	Simplicity of operation (viable)				√

B.	**Design Aspects**		
4*	Clarity of usage instructions		√
5	Consistency of features within the media		√
6*	Accessibility of language for students		√
7	Appeal of the media's design		√
8	Alignment of visuals and effects with intended values		√
9	Appropriateness of technical specifications	√	
10	Interactivity of the media		√
11	Suitability of the media's layout		√
C.	**Technical Quality Aspects**		
12	Alignment with user needs		√
13	Suitability for environmental objectives		√
14	Contribution of all components to value internalisation		√
D.	**Software Aspects**		
15	Maintainability (ease of management)		√
16	Usability (simplicity and ease of operation)		√
17	Compatibility (operability across diverse community contexts)		√
18	Reusability (potential for further development and reuse)		√

Based on the media validation results conducted by experts in urban waste processing technology (Table 4), the Buried Compost Bin (BCB) medium was evaluated as being consistent with the principles of both hardware and software application. An application medium is considered effective and efficient if it encompasses four key principles: ease of understanding, ease of operation, specific value requirements for work facilitation, and particular goal requirements (Rahmah et al., 2025). These four principles are inherent in the BCB medium, namely learnability, flexibility, robustness, and attitude. Accordingly, the validation results indicate that the BCB medium embodies these characteristics: learnability, which promotes the learning process; flexibility, allowing implementation across various social strata; robustness, ensuring alignment with environmental objectives; and attitude, reflecting conformity with value aspects. The expert validation findings thus provide a foundation for the researchers to proceed with field testing of the BCB medium as part of an effort to engineer behavioural change among students.

Implementation

Following validation of the BCB waste bin medium by two experts in urban waste processing technology, the medium was found to be consistent with the principles of both hardware and software applications. According to Dix et al. (2004), an effective and efficient media application must incorporate four key principles: ease of understanding, ease of operation, specific value requirements for operational simplicity, and alignment with defined objectives. These principles—commonly referred to as learnability, flexibility, robustness, and attitude—are all embodied in the BCB waste bin medium. Specifically, the BCB demonstrates learnability through its facilitation of learning processes, flexibility by enabling use across varied social contexts, robustness by aligning with environmental goals, and attitude by supporting values-based objectives. The outcomes of the validation process provided a solid foundation for the researchers to proceed with trialling the BCB medium in order to foster behavioural change among students.

The validated BCB waste bin medium was subsequently implemented at Muhammadiyah III Primary School in Cirebon, as part of a developmental research initiative aimed at enhancing students' environmental awareness and promoting science-informed behaviours. The Pancasila Student Profile

Strengthening Project (P5), designed to facilitate experiential learning that reinforces Pancasila-based competencies and character (Rizky Satria et al., 2022), aligned closely with the objectives of the BCB trial. As such, the researchers integrated the BCB medium as a learning resource to re-engineer environmental consciousness, embedding epistemological principles of education within the learning process. This rationale formed the basis for integrating the P5 programme with the research.

Project-based activities engaged students in a series of tasks involving challenging themes, structured to promote investigation, problem-solving, and decision-making (Darmuki et al., 2023; Thomas et al., 2015; Issa & Khataibeh, 2021). The study involved 100 students and six teachers as respondents. The implementation of the BCB medium aimed to cultivate environmental awareness and encourage habitual waste segregation practices. Through the re-engineering of scientific principle internalisation, the BCB medium enabled students to sort organic and inorganic waste appropriately prior to disposal, ensuring consistency with the specific type and composition of the waste generated.

Evaluation

This developmental research evaluated the limited capacity of individuals to manage natural resources by implementing the BCB medium in conjunction with the P5 programme, maximising a project-based approach. The process skills embedded in each P5 phase were enhanced by efforts to re-engineer students' environmental consciousness while preserving their daily behavioural patterns related to self-generated waste. This approach proved effective in engaging students without disrupting their habitual reflexes, particularly their everyday waste management practices. The reinforcement of Pancasila-based competencies and character inadvertently evaluated environmental awareness, as evidenced by students' growing sense of responsibility for their own waste.

Project-based learning not only fosters process skills across various aspects of life but also enhances awareness, guiding positive behavioural change (Sijabat et al., 2025). Furthermore, it cultivates a culture of diligence, thereby shaping students' consciousness. The results indicate that environmental awareness, as a foundation for behaviour, was evident throughout the P5 implementation. The P5 programme provided experiential learning opportunities, encompassing exploration, investigation, comprehension, problem-solving, and conclusion-drawing, which underpinned students' attitudes and behaviours. This was measured using a test comprising seven affirmation items to assess students' perceptions of environmental components and seven confirmation items to evaluate their behaviours towards waste. The findings revealed that 60 out of 100 students demonstrated behaviours confirmed by their level of environmental awareness, compared to baseline data indicating that only 12% of the 100 students initially exhibited behaviours unconfirmed by their awareness, as assessed by the seven affirmation items. This represents a 48% increase in students' environmental awareness, a significant outcome of the efforts to re-engineer their environmental consciousness.

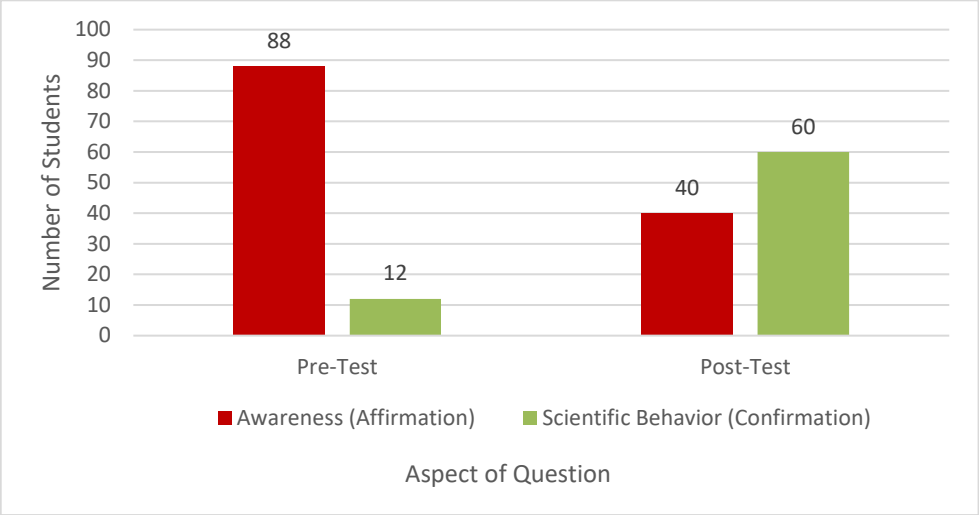

Figure 2: Graph Comparing Pre- and Post-Test Awareness and Scientific Behavior

Based Figure 2, which showed that only 12% of the 100 students displayed behaviours not aligned with their environmental awareness, as measured by the seven affirmation items, a significant improvement was observed. The subsequent findings revealed a 48% increase in students' environmental awareness, a notable outcome of the initiative to foster enhanced environmental consciousness among learners.

DISCUSSIONS

Analysis Stage

Previous observational research indicates that many individuals hold a narrow perspective on waste, viewing it solely as useless material unsuitable for reuse (Raveesh et al., 2015; Evode et al., 2021). This misconception exacerbates their lack of responsibility towards managing their own waste. Survey results obtained by the researchers revealed that fewer than one in ten individuals expressed reluctance to dispose of waste irresponsibly, confirming the prevalence of such attitudes. Consistent with other studies, reasons for improper waste disposal include perceptions that waste materials are valueless, unusable, or require disproportionate time and cost to repurpose (Shukla & Tyagi, 2013; Ahmad et al., 2024; Pilapitiya & Ratnayake, 2024). Field data underscore the critical need to address the effectiveness and efficiency of waste management to counter perceptions of it being difficult, distasteful, or financially wasteful.

Design Stage

The design stage was informed by empirical data and findings from seven years of prior research, which explored three waste processing techniques: composting, bioconversion, and bio-enzymatic methods. These techniques informed the development of the BCB medium as a tool for managing household organic waste. Key findings revealed that these methods often produced coarse, aesthetically unappealing waste materials unsuitable for use as planting media, as not all organic waste fully decomposes within three to six months, requiring extended periods to return to soil. Additionally, composting and bioconversion involve a harvesting phase for maggot-processed waste (kasgot), which is perceived as challenging and unpleasant. These methods also demand additional time to refine sorted waste for optimal maggot processing, a step the researchers facilitated using a blender to produce suitable planting media. However, such techniques are neither effective nor efficient for

individuals with varying levels of busyness, diverse social backgrounds, or limited agricultural expertise, reinforcing perceptions of waste management as complex, burdensome, unhygienic, and costly (Sutisno & Novianawati, 2021).

Consequently, the researchers combined three established waste management concepts—biopore pits, bioconversion, and Islamic burial systems—to develop the BCB embedded waste bin for household organic waste. This design integrates the operational principles of composting, bioconversion, biopore systems, and Islamic burial without requiring waste refinement or harvesting. Embedding organic waste in soil aligns with soil and land conservation principles, enabling microorganisms to complete decomposition naturally. This process, occurring at a depth of approximately two metres, supports soil pore formation and activates new material from organic remains, offering a communal solution for organic waste management (Sutisno & Novianawati, 2021; Novianawati & Sutisno, 2022).

Developing Stage

Amid growing environmental pollution concerns, few individuals demonstrate awareness of the issue. Field data, as outlined above, prompted the researchers to prioritise fostering human resource capacity for natural resource management. This aligns with findings by Abdel-Shafy and Mansour (2018) and Michiko (2000), who argue that low environmental awareness, reflected in poor behavioural respect for the universe, underscores the urgent need to renew natural resources and their surroundings. Following the design of the BCB medium, the development stage involved modifying conventional waste bins into the BCB format and validating it with relevant experts. This medium promotes advanced natural resource management skills, resonating with the Islamic concept of humans as stewards of the Earth (khalifah fil'ard), or universal managers, as defined by the Indonesian Ministry of Education (2008) and supported by Suryadi (2024) Such stewardship extends beyond resource utilisation to responsible management and protection (Satmoko, 2024). Developing the BCB medium to serve as a learning resource for sustainable environmental management remains underexplored, particularly given widespread indifference to self-generated waste, which reflects poorly internalised values and a lack of critical, science-based knowledge (Aprilia, 2021; Sutisno, 2016).

Implementation Stage

Human behaviour falls within the epistemological domain of education, where the motivation to manage waste emerges from the internalisation of environmental values. Behavioural tendencies are shaped by sensory and cognitive exposure to information, which forms subconscious principles influencing attitudes, including towards self-generated waste. These tendencies develop through experiential learning, reinforced by educational tools that support value internalisation and shape thinking paradigms (Schuman-Olivier et al., 2020; Sutisno, 2023; Sutisno, 2016). This principle underpinned the implementation stage, where the BCB medium was trialled to assess its effectiveness as a learning resource for enhancing environmental awareness and fostering responsible waste management behaviours.

The universe, comprising biotic and abiotic components, including waste, inherently supports learning experiences that yield scientifically informed behaviours. The trial, conducted at Muhammadiyah III Primary School, integrated waste as an inseparable part of students' daily activities, transforming it into a learning resource. The BCB medium's implementation promoted scientific behaviours through waste categorisation (biotic and abiotic), involving observation, exploration, analysis, classification, and conclusion-drawing—key stages of scientific behaviour (Ellizar et al., 2018). By integrating environmental consciousness re-engineering with the Pancasila Student Profile

Strengthening Project (P5), this research advanced sustainable development, preparing human and natural resources for a reliable future.

Evaluation Stage

According to the learning theorists Miller and Dollard, student behaviour is the outcome of engagement and learning processes, with responses elicited by environmental stimuli (Schulz, 1976). This developmental study found that efforts to enhance students' environmental awareness yielded significant outcomes, including science-supported behavioural changes.

A pre-test comprising seven items measuring environmental awareness and seven items assessing scientific behaviour revealed low initial levels of awareness. Specifically, 88 out of 100 students exhibited scientific behaviours that were not underpinned by conscious environmental awareness, while only 12 students demonstrated behaviours that were aligned with such awareness.

Following the implementation of the five phases of the Pancasila Student Profile Strengthening Project (P5), which focused on re-engineering environmental consciousness through the use of the BCB medium, post-test results showed a marked improvement. In contrast to the baseline of 12 students, 60 out of 100 students displayed behaviours consistent with their environmental awareness—a 48% increase. This substantial improvement in both awareness and behaviour underscores the effectiveness of the P5 programme in conjunction with the BCB medium in fostering responsible environmental stewardship among students.

CONCLUSION

The findings of this study indicate that the development of the BCB medium not only enhances environmental awareness but also serves as a sustainable learning resource that remains integrated with individuals' daily routines—such as the act of waste disposal. The use of the BCB medium empowers individuals to manage natural resources responsibly. Given its advantages, the BCB medium demonstrates strong potential for effective source-level waste management. The BCB medium, successfully developed through the ADDIE model, can be widely adopted by various communities, including both formal and non-formal educational institutions. In terms of functionality, the principles of effectiveness and efficiency are inherently embedded in the operational mechanism of the BCB medium, making it a practical and scientifically sound tool for environmental education and waste processing. One limitation identified during the study relates to the installation process of the BCB medium. The current design requires a circular space with a diameter of 45 cm, which may pose constraints in certain settings. Excavation can be physically demanding, and site conditions are not always conducive to proper installation. Therefore, further interdisciplinary research is needed to develop supporting tools and techniques that facilitate more flexible and accessible installation methods. Additionally, future studies should focus on policy-related aspects, particularly regarding government regulations on waste management in primary schools. It is important to explore how such policies can be integrated with other national programmes. Another critical area for further investigation is the potential effectiveness of the BCB medium in flood-prone areas. These recommendations aim to support broader national efforts toward achieving a waste-free Indonesia by 2045, underscoring the importance of continued innovation and policy alignment in environmental education and sustainable waste management.

ACKNOWLEDGMENT

We express our profound gratitude for the Fundamental Research Grant from the Directorate of Muhammadiyah Higher Education (Muhammadiyah Research). Muhammadiyah Cirebon III Elementary School is also acknowledged for its participation in this developmental research. The

ongoing support and guidance from the Research Board of Universitas Muhammadiyah Cirebon enabled the researchers to implement this program. The authors express gratitude for their assistance.

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