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Strengthening Waste-Care Culture Through School–Community Synergy: A Quasi-Experimental Model

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ABSTRACT

Background: Indonesia's 2025 SIPSN data show 24.8 million tonnes of annual waste, of which 65.51% remains unmanaged—dominated by food waste (40.76%) and plastics (20.49%). Closing this gap requires behavioural change at the school and household level, not merely additional infrastructure.
Objectives: This study examines whether an integrated school-education and community-empowerment intervention can move the three constitutive dimensions of waste-care culture—knowledge, attitude, and behaviour—within an eight-week cycle.
Method: A quasi-experimental one-group pretest–posttest design was applied to simulated data covering 40 participants (20 students, 20 community members). The intervention comprised eight modules spanning waste literacy, school routine formation, waste-bank simulation, organic processing, social campaigns, and collaborative action. A 20-item five-point Likert questionnaire operationalised the three dimensions; analyses included paired samples t-test, Cohen's d_z, and normalized gain.
Result: Total scores rose from 67.18 (SD = 5.53) to 80.93 (SD = 9.87). The paired t-test yielded $t(39) = 11.70$; $p < 0.001$, with a 95% CI of 11.45–16.05 points. The effect size was very large ($d_z = 1.85$); class N-Gain reached 0.42 (medium category). Response heterogeneity (13 low, 19 medium, 8 high gainers) emerged as a substantive finding.
Conclusion: Education and community empowerment can be treated as a single change system; however, the single-group design and the simulated data require field verification with a control group before any generalisation can be made.

INTRODUCTION

The waste problem in Indonesia has long ceased to be a mere sanitation issue. It has evolved into a public-governance challenge intersecting with culture,

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education, and ecological justice. Law No. 18 of 2008 on Waste Management explicitly frames the surge in volume, variety, and characteristics of waste as a consequence of population growth and shifting consumption patterns, and it underlines that management which neglects environmental principles will turn into a public-health threat (Government of the Republic of Indonesia, 2008). This normative position places behavioural change on equal footing with infrastructure provision.

Data from the National Waste-Management Information System (SIPSN) for 2025 reinforce this urgency. Of 244 reporting districts and cities, the national waste generation reached 24.8 million tonnes per year, with households as the dominant source (56.7 percent). Of this volume, only 34.49 percent was successfully managed, while 65.51 percent—roughly 16.25 million tonnes per year—escaped formal management and entered the environment (Ministry of Environment and Forestry, 2025a). Compositionally, food waste was the largest contributor at 40.76 percent, followed by plastic at 20.49 percent, wood and twigs at 13.29 percent, and paper and cardboard at 11.25 percent (Ministry of Environment and Forestry, 2025a). This profile places two intervention fronts in the most strategic position: organic-waste management at the household level and single-use-plastic reduction in schools and communities. The gap between waste generation and management capacity will not be closed by simply adding final-disposal sites. What is required is a behavioural shift at the most capillary levels—households, schools, and citizen communities.

The social ecosystem of waste management does not, however, start from zero. The Ministry of Environment's Info3R dashboard records 13,401 unit waste banks and 445 main waste banks scattered across regions (Ministry of Environment and Forestry, 2025b). Political commitment is also strengthening through the 2025 National Coordination Meeting on Waste Management, which set the target of an "Indonesia Free of Waste 2029" under the theme "Toward 100% Waste Management" (Ministry of Environment / Environmental Control Agency, 2025). These institutional figures and policy directions show that the social apparatus is in place; what is not in place is the assurance that its mere existence automatically cultivates a waste-care culture. This is the gap this article addresses: how to convert institutional availability into a collective practice that endures.

Education occupies a strategic position within this gap. Law No. 20 of 2003 on the National Education System governs not only the rights and obligations of citizens but also the systemic involvement of communities in education (Government of the Republic of Indonesia, 2003). At the school level, the

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institutional framework for cultivating environmental awareness is reinforced by Regulation of the Minister of Environment and Forestry No. 5 of 2025 on the Adiwiyata Programme, which structures the entire cycle from planning, implementation, and recognition to monitoring, evaluation, and funding (Minister of Environment and Forestry, 2025). Schools therefore have a formal basis to act as structured units of behavioural change rather than sporadic ones.

A number of Indonesian studies indicate that genuine transformation only emerges when formal education fuses with community-driven movements. A study of waste banks in Yogyakarta showed that the practice serves a dual function as both waste management and a medium of environmental education (Suryani, 2014). A household-participation study in Depok demonstrated that citizen involvement is strongly influenced by service proximity, information access, and the dominant type of waste produced (Hartati, Soewondo, & Soemantojo, 2022). Research in Bantul adds that waste banks have impacts across health, socio-economic, educational, and partnership dimensions (Mahyudin, 2017). These three converging findings direct attention to the research question framed here: to what extent can an integrated intervention combining school education and community empowerment move the three dimensions of waste-care culture—knowledge, attitude, and behaviour—within an eight-week cycle?

Building on this question, the article offers three contributions. First, it proposes a three-layer conceptual framework that links school education, community empowerment, and regulatory governance as a single change system rather than three parallel domains. Second, it presents a quantitative analytical model based on simulated data that other researchers can replicate before moving to full-scale field testing. Third, it derives operational recommendations usable by schools, communities, and local governments as units of waste-management policy implementation at the local scale.

METHODS

This study operationalize a quantitative quasi-experimental design with a one-group pretest–posttest layout, conventionally denoted O_1 X O_2. The notation indicates the sequence of three events: a pre-measurement (O_1), the delivery of the intervention (X), and a post-measurement (O_2). The design is suited to observing score shifts within a single group before and after treatment. Its consequence is also acknowledged: without a control group, internal validity is weaker than in a true experimental design, so every interpretation must proceed with methodological caution.

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Owing to access considerations, ethical feasibility, and the limited scope of a model paper, the data analysed are simulated. The simulation was designed to resemble plausible field conditions: baseline scores at a moderate level, real between-participant variation, and a non-uniform intervention effect. The basic assumptions are summarised in Table 1.

Table 1. Basic Assumptions of the Study Simulation

Component	Specification
Site	Data SIPSN 2025
Sampling technique	Convenience sampling
Significance level	$\alpha = 0.05$
Maximum score	100 (0–100 index)
Simulation pattern	Moderate baseline scores, heterogeneous gains, bounded 0–100
Measurement focus	Knowledge, attitude, and waste-care behaviour

Particular emphasis is placed on the behavioural dimension on specific theoretical grounds: a waste-care culture can only be considered strong when daily routines genuinely shift, not when declarative knowledge alone improves. The simulation pattern was therefore designed so that gains in the behavioural dimension would be slightly more pronounced than in the other two dimensions, as shown in the Results section.

The independent variable is the waste-care-culture strengthening programme delivered through school education and community empowerment. The dependent variable is waste-care culture, operationalised through three constitutive dimensions: knowledge, attitude, and behaviour. The instrument grid was derived from four sources—the Adiwiyata regulatory framework, literature on environmentally oriented school culture, waste-bank participation studies, and community-based waste-management research. The instrument structure is presented in Table 2.

Table 2. Measurement Instrument Structure

Dimension	Core Indicators	Items	Sample Statement
Knowledge	Understanding of waste types, the 3R principle, waste-bank mechanisms, sorting procedures, ecological impacts, and local rules	6	"I understand the difference between organic and inorganic waste."
Attitude	Personal responsibility, social norms, willingness to engage, self-efficacy, and shared commitment to a clean environment	7	"I feel responsible for reprimanding people who litter."

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Behaviour	Routine sorting, single-use-plastic reduction, deposit at waste banks, communal-work participation, and organic-waste processing	7	"I routinely sort waste before disposal or deposit."

Scoring uses a range of 1 (strongly disagree) to 5 (strongly agree). For reporting and cross-dimensional comparability, raw scores were transformed to a 0–100 index using a standard linear formula. The total score per participant is the mean of the three subscale indices, so it also lies within the 0–100 range. In a real field implementation, the instrument must be examined for content validity through expert appraisal and for reliability via Cronbach's α. Because this section concentrates on aggregate-level scores from simulated data, item-level reliability is not reported here.

The intervention was designed to integrate classroom instruction, cultural habituation, waste-management practice, and community-empowerment action. Module construction drew on studies of environmentally oriented school culture, the role of waste banks, and citizen engagement, so that each week contributes a measurable intermediate output. The eight-week design is shown in Table 3.

Table 3. Eight-Week Integrated Intervention Plan

Wk.	Module	Focus	Core Activities	Intermediate Output
1	Orientation & baseline audit	Problem mapping	Pretest, classroom and household waste audit, learning contract, identification of accumulation hotspots	Problem map and baseline
2	Waste literacy	Foundational knowledge	Waste typology, 3R principle, environmental impacts, key regulations, case discussion	Initial conceptual understanding
3	School culture	Habituation	Sorted-bin arrangement, picket schedule, classroom slogans, teacher–student commitment	Daily routines established
4	Waste bank	Circular economy	Deposit simulation, simple bookkeeping, classification of economically valuable waste	Waste-bank practice experience
5	Organic processing	Skills	Composting or eco-enzyme production, output observation, household-task allocation	Organic-processing skills
6	Community campaign	Social communication	Poster production, social-media content, peer education, mini outreach to families	Change message disseminated

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7	Collaborative action	Collective participation	Communal work, weighing, volume reporting, group reflection	Mutual-cooperation experience
8	Reflection & consolidation	Sustainability	Posttest, reflection workshop, commitment certificate, follow-up plan	Post-programme commitment

Data analysis proceeded in four ordered stages. First, descriptive statistics produced means, standard deviations, minimum, and maximum values for each dimension at both measurement points. Second, the Shapiro–Wilk test was applied to difference scores to verify the normality assumption. Third, if the assumption was met ($p > 0.05$), a paired samples t-test was used; if not, the prepared alternative was the Wilcoxon signed-rank test. Fourth, effect size was computed using Cohen's d_z the mean difference divided by the standard deviation of differences—with conventional interpretive thresholds of 0.2 (small), 0.5 (medium), and 0.8 (large) (Cohen, 1988). Learning effectiveness was estimated via normalized gain (Hake, 1998), with the formulae $g = \frac{(S_{post} - S_{pre})}{(100 - S_{pre})}$ and $d_z = \frac{M_D}{SD_D}$. N-Gain categories follow Hake's classic divisions: high ($g > 0.70$), medium ($0.30 \leq g \leq 0.70$), and low ($g < 0.30$). N-Gain was computed at two levels: the class gain, derived from group pretest and posttest means, and the average individual gain, the arithmetic mean of each participant's gain. Reporting both levels enables a richer diagnosis of response heterogeneity—an aspect frequently obscured by aggregate statistics. Data processing was performed in Python 3 using NumPy and SciPy.

RESULTS AND DISCUSSION

Table 4 summarises the descriptive statistics of pretest, post-test, and mean gain across the four measurement variables. At the aggregate level, every dimension shows a consistent post-intervention rise. The total score climbed from 67.18 to 80.93—a 13.75-point shift on the 0–100 scale. Notably, the largest gain occurred on the behavioural dimension (14.52 points), the dimension most closely tied to everyday cultural habituation.

Table 4. Descriptive Summary of Pretest and Posttest (n = 40)

Variable	M pre	SD pre	Min pre	Max pre	M post	SD post	Min post	Max post	M gain
Knowledge	69.82	6.08	55	83	83.15	9.80	64	99	13.32
Attitude	68.12	5.67	57	77	81.53	10.59	60	99	13.40
Behaviour	63.58	6.62	49	77	78.10	10.19	60	97	14.52

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Total Score	67.18	5.53	56	79	80.93	9.87	62	95	13.75

To make the pattern visually explicit, Figure 1 shows the pretest and posttest means across the four variables, with standard-deviation error bars.

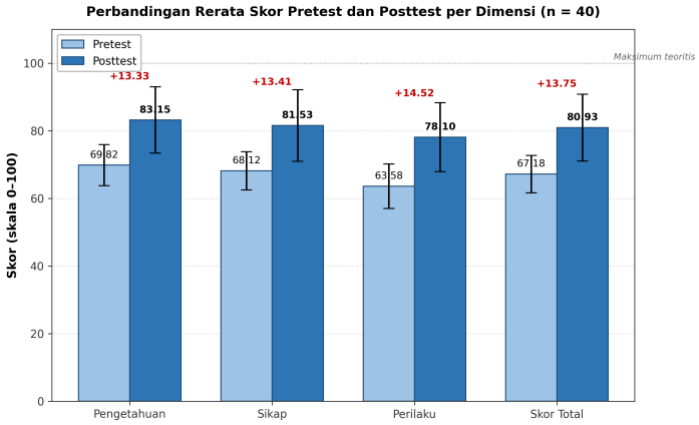

Figure 1: *Pretest vs. Posttest Bar Chart*

Figure 1. Comparison of pretest and posttest means across the four measurement variables. The change profile across the three dimensions can also be read on the radar diagram in Figure 2. The display shows that the posttest triangle is consistently larger than the pretest triangle, with the most visible expansion along the behaviour axis—a visual confirmation of the numerical findings in Table 4.

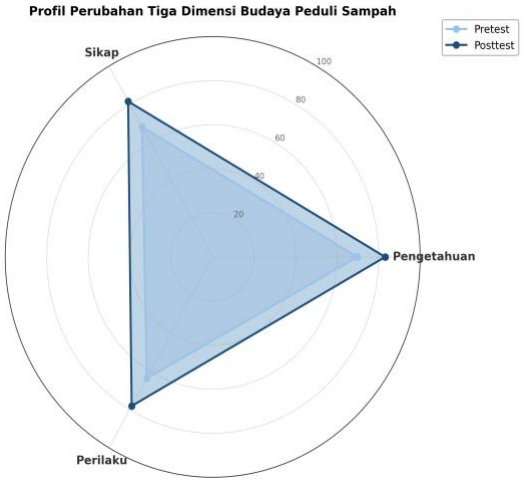

Figure 2: *Radar Chart of Three Dimensions*

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Distribution and Response Heterogeneity

Mean summaries tend to mask the diversity of individual experience. The total-score distribution is therefore presented in Figure 3 as a boxplot paired with an individual-points strip plot. The visualisation reveals two simultaneous shifts: the median moves upward, and the interquartile range widens at posttest. This widening is substantively meaningful—some participants moved very rapidly toward the maximum score while others moved more slowly.

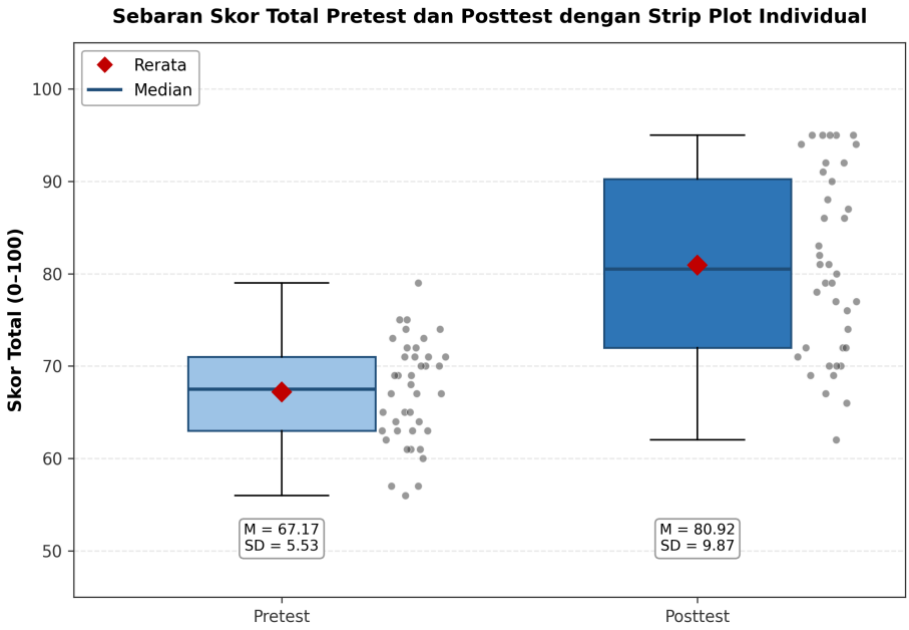

Figure 3: Boxplot with Individual Points

Normality, t-Test, Effect Size, and N-Gain

Table 5 summarises the inferential testing for the four measurement variables. In all four cases, the difference scores satisfied the normality assumption, with Shapiro–Wilk p-values exceeding 0.05, so the use of a paired samples t-test is procedurally legitimate. The t-statistic on the total score reaches 11.70 with 39 degrees of freedom and $p < 0.001$. The 95% confidence interval for the mean total-score difference spans 11.45 to 16.05 points, lying entirely on the positive side and excluding zero.

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Table 5. Normality, t-Test, Effect Size, and N-Gain Results

Variable	W (S–W)	p (norm.)	Decision	Test	t-stat	p (test)	d_z	M N-Gain (Cat.)
Knowledge	0.9688	0.3301	Normal	Paired t	10.1121	<0.001	1.60	0.4528 (Medium)
Attitude	0.9686	0.3239	Normal	Paired t	10.7596	<0.001	1.70	0.4430 (Medium)
Behaviour	0.9718	0.4106	Normal	Paired t	10.7804	<0.001	1.70	0.4078 (Medium)
Total Score	0.9558	0.1203	Normal	Paired t	11.7029	<0.001	1.85	0.4362 (Medium)

The effect size on the total score reaches d_z = 1.85, which qualifies as very large under the Cohen convention. Comparable values exceeding the 0.8 threshold appear in all three constitutive dimensions, so the change pattern is not confined to a single aspect. At the learning level, the class N-Gain computed from total pretest and posttest means yields $g = \frac{(80.93 - 67.18)}{(100 - 67.18)} = 0.42$, which falls in the medium category. The mean individual N-Gain of 0.44 confirms this aggregate finding.

The distribution of individual N-Gain values is shown in Figure 4. Thirteen participants fall into the low category, nineteen into the medium category, and eight into the high category. The distribution conveys a two-way message: the programme is effective on average, yet a third of participants remain in the low category a figure that should not be obscured by aggregate success.

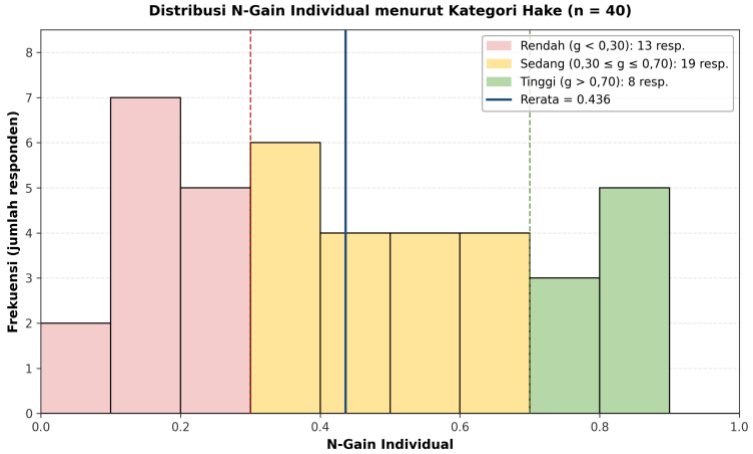

Figure 4: *N-Gain Distribution Histogram*

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Heterogeneity Analysis: Baseline Score and Gain

To probe the source of this heterogeneity, the relationship between baseline score and gain was examined in Figure 5. The linear correlation between pretest and gain stands at $r = 0.141$ ($p > 0.05$), meaning that gain is not significantly determined by baseline level. The implication is interesting: low responses in some participants cannot be explained solely by ceiling effects—participants with moderate baselines still ended up in the low N-Gain category. A more plausible explanation points to non-score factors such as motivation, family support, engagement continuity, and mentoring quality.

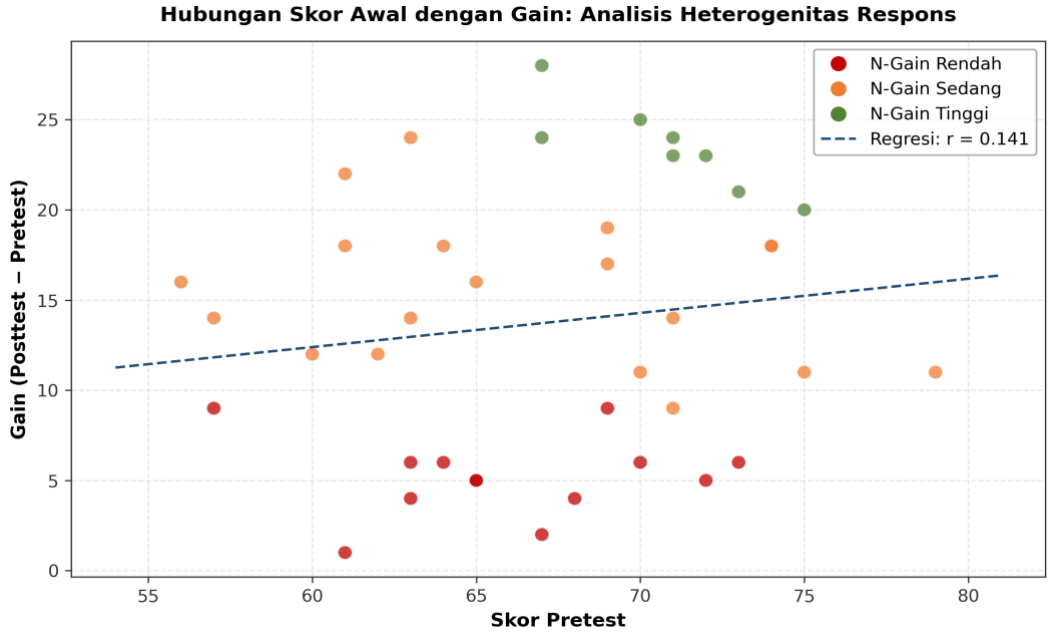

Figure 5*: Pretest vs. Gain Scatter Plot*

Why Behaviour Shifts Most Sharply

The most substantive finding from this simulation is not statistical significance—which is to be expected in a one-group design with structured intervention—but the pattern of gain distribution across dimensions. Behaviour, the dimension theoretically hardest to change, in fact moves most sharply (14.52 points). This pattern aligns with Permana and Ulfatin's (2019) argument that environmental-care culture grows from institutionally enforced routines, not from

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information delivery alone. Modules in weeks 3 to 7 of this intervention were designed precisely on that logic: sorted bins become permanent, the picket schedule becomes routine, and waste-bank deposits become repeated. This curated repetition explains why behaviour scores not only rise but rise the fastest.

The argument is reinforced by Suryani's (2014) findings on waste banks as a medium of direct education and by Mahyudin (2017), who positions community outreach and training as catalysts of habit change. In other words, an intervention combining literacy and practice is theoretically more likely to move behaviour than one that merely accumulates knowledge. This simulation result is not final proof of that proposition but offers an early, consistent indication worth field verification.

Heterogeneity as Programme Diagnostic

The thirteen participants with low N-Gain values are a more informative finding than a d_z of 1.85. Aggregate statistics risk concealing the sub-population that most needs additional support. Because the pretest–gain correlation is non-significant ($r = 0.141$), the ceiling-effect explanation can be set aside. What remains is a more operational hypothesis: engagement continuity, mentoring quality, and family-ecosystem support are likely the dominant determinants.

The practical implication is clear. A programme designed as a single package for all participants tends to leave a sub-population underserved. A tiering approach providing an additional mentoring track for participants identified as low performers by mid-programme offers a directly testable design modification. This approach also resonates with Hartati, Soewondo, and Soemantojo (2022), who showed that participation is strongly shaped by household-specific conditions rather than by population-average characteristics.

Implications for Schools, Communities, and Local Government

For schools, three practical recommendations arise from the result pattern. First, integrate waste themes into project-based learning across subjects rather than into incidental cleanliness contests. Second, translate cleanliness rules into measurable indicators: percentage of sorted waste, volume successfully reduced, frequency of waste-bank deposits. Third, link school habituation to the home and community organisations so that behaviours do not stop at the school gate. These three steps align with the Adiwiyata cycle (Minister of Environment and Forestry, 2025).

For communities, the focus should be directed at the three participation determinants identified in the literature: service proximity, information access, and

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benefit visibility. School–community partnerships should locate deposit points nearby, maintain consistent schedules, set up transparent bookkeeping, and offer tangible social recognition—the last of which is often more effective than a single economic incentive.

For local governments, this model is suitable as a micro-implementation unit of the national waste-management policy framework. Law No. 18 of 2008 places behavioural change and citizen participation as components of waste management; Government Regulation No. 81 of 2012 frames household-waste management; Presidential Regulation No. 97 of 2017 sets the national strategic direction; and Regulation of the Minister of Environment and Forestry No. 14 of 2021 specifically regulates waste banks. School–community partnerships can wrap this entire framework into a concrete operational unit at the village or sub-district scale.

Limitations and Ethical Considerations

This article carries two limitations that must be stated openly. First, the analysed data are simulated. Although the patterns were designed to resemble plausible field conditions, the figures here are not generated from field measurement and must not be treated as evidence of programme effectiveness. Second, the one-group pretest post-test design is intrinsically vulnerable to internal-validity threats testing effects, history, maturation, and regression to the mean which can only be addressed by adding a comparison group. Hence, the significant results presented here should be read as an illustration of an analytical model, not as generalisable evidence.

In a real field implementation, several ethical requirements must be met. Informed consent of participants, institutional permission from the school and community leadership, parental or guardian consent for under-age participants, and identity confidentiality are foundational prerequisites. Equally important, the programme must avoid sanctions that shame participants who have not yet been able to change. A waste-care culture is built through example, mentoring, and participation not through shame or fear. This ethical discipline is not merely procedural; it is a precondition for sustainability.

CONCLUSION

Drawing on regulatory analysis, synthesis of Indonesian literature, and the simulation analysis conducted, this article positions the strengthening of waste-care culture as a project of social education not a stand-alone sanitation project. Schools contribute the value structure, curriculum, and routines; communities contribute the practice space, normative reinforcement, and post-programme sustainability. In a simulation with n = 40, their synergy yielded a 13.75-point rise in total scores ($t = 11.70$; $p < 0.001$), an effect size of $d_z = 1.85$, and a medium-category N-Gain with

the substantive caveat that response heterogeneity remains real and demands specific attention.

Three further research directions deserve priority. First, replication with a quasi-experimental design that includes a comparison group, so that internal validity can be strengthened and causal claims can be made legitimately. Second, measurement based on objective behavioural indicators volume of sorted waste, frequency of deposits at waste banks, number of participating families to complement self-report measures, which are vulnerable to social-desirability bias. Third, a follow-up measurement three to six months after the intervention to test whether behavioural change endures or fades along with the end of mentoring. With these three extensions, the model still simulative here can be tested as a methodologically stronger and more policy-relevant field intervention.

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