

Developing a Socio-Ecological L-E-A-D Training Model for Green Skills and Circular Economy Agency

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Abstract

Background – Village waste banks can connect household waste separation with circular value creation, but participation, green competence, and continuity of community action often remain uneven.

Research Urgency – Existing waste-bank activities frequently emphasize awareness or sorting practice without integrating local ecological diagnosis, adult learning, supervised application, and community agency in one coherent nonformal training sequence.

Research Objectives – This study developed a socio-ecological L-E-A-D training model and examined preliminary short-term changes in green knowledge, green attitudes, green skills, and circular economy agency among adult community participants.

Research Method – The study used three development phases: qualitative needs assessment, prototype development with expert review, and a pre-experimental one-group pretest-posttest field study involving 30 purposively recruited participants at the Mugarsari Waste Bank, Tasikmalaya. A 20-item measure covered four outcome domains. Validation indices must be completed from the original validation records before submission.

Research Findings – The overall mean increased from 58.60 to 86.23. The recalculated normalized gain was 0.667. Based on the reported summary, the mean paired difference was 27.63 (SDdiff = 2.41), 95% CI [26.73, 28.53], $t(29) = 62.70$, $p < .001$, Cohen's $d_z = 11.45$. The unusually large statistic and effect size require verification against raw data or software output.

Research Conclusion – The results indicate preliminary short-term within-group improvement after training, but they do not establish causal effectiveness because the study lacked a control group, long-term follow-up, and fully reported validation evidence.

Research Novelty/Contribution – The study operationalizes socio-ecological andragogy as L-E-A-D: Local Ecology, Education, Action, and Development, connecting place-based problem mapping, participatory adult learning, supervised waste-management practice, and development of community agency.

Keywords: adult learning; circular economy; community empowerment; green skills; L-E-A-D training model; waste bank

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INTRODUCTION

The circular economy seeks to retain the value of products and materials through reduction, reuse, repair, recovery, and regeneration rather than the linear take-make-dispose pattern. Current scholarship also stresses that circularity is not only a technical system. It requires changes in everyday practice, institutions, and social participation (Jaeger-Erben et al., 2021; Kirchherr et al., 2023). In Indonesia, integrating circular principles into municipal and community waste management remains important because household waste segregation, financing, infrastructure, and participation vary across locations (Wikurendra et al., 2024).

Waste banks provide a locally embedded mechanism for collecting recyclable materials, building environmental awareness, and creating limited economic value. Indonesian evidence shows that these organizations can strengthen environmental resilience, yet their outcomes depend on sustained participation, learning capacity, institutional support, and transparent management (Abdillah et al., 2024; Ulhasanah et al., 2025). Large-scale evidence also indicates that public awareness, worker conditions, technical capacity, and institutional arrangements shape willingness to separate, reuse, and purchase recycled products (Pambudi et al., 2025).

The shift from waste collection to circular value creation requires green skills. These skills combine knowledge, practical competence, values, systems thinking, and the capacity to act on sustainability problems (Bianchi et al., 2022; Fuchs, 2024). In nonformal and community settings, competence grows through relevant tasks, participation, mentoring, and accessible learning resources rather than through information transfer alone (Firdaus et al., 2026; Hayat et al., 2024; Hidayat et al., 2026; Suminar et al., 2024). Green education can support the Sustainable Development Goals when competence development is connected with concrete environmental action (Akinsemolu & Onyeaka, 2025).

Adult learning provides a relevant pedagogical basis because participants bring prior experience, immediate responsibilities, and problem-centered learning needs. Local adult-learning systems are stronger when opportunities are accessible, socially supported, and connected with the surrounding socio-spatial environment (Broek et al., 2024). JoNE studies similarly emphasize contextual curriculum, participatory training, project-oriented learning, systematic program management, and evaluation in nonformal education (Akhadi & Shofwan, 2024; Djibu et al., 2024; Ilyas et al., 2025; Kurniawan et al., 2026; Sari et al., 2024). A socio-ecological andragogy framework extends these principles by treating local environmental conditions as both the learning context and the object of collective action. It links individual capability with household routines, community organizations, local governance, markets, and environmental systems. Community-based nonformal education can strengthen local capability when learning is participatory, relevant to livelihood conditions, and supported by institutional collaboration (Ambarini et al., 2025; Hayat et al., 2026; Nugroho et al., 2024). This orientation is also consistent with adult learning for active citizenship and sustainable development (UNESCO Institute for Lifelong Learning, 2022).

Existing community waste programs frequently emphasize awareness campaigns, waste sorting, or short practical demonstrations. Such activities may improve knowledge but do not automatically establish durable behavior, enterprise capability, or institutional continuity. Indonesian and international evidence shows that circular transition depends on public participation, social organization, fair recognition, technical capacity, and supportive governance (Abdillah et al., 2024; Castillo-Ospina et al., 2025; Gerassimidou et al., 2025; Gutberlet, 2021; Pambudi et al., 2025; Suryawan & Lee, 2025; Ulhasanah et al., 2025; Wikurendra et al., 2024). A specific research gap therefore concerns how a place-based adult training sequence can connect four functions: diagnosing local ecological problems, building green competence, applying skills to waste practices, and developing community agency. Recent studies separately document informal learning in waste work, community capability, entrepreneurship training, and circular-economy participation (Amin et al., 2025; Amin et al., 2026; Angriani et al., 2024; Cook et al., 2024; Susilo et al., 2026; Ilyas et al., 2025; Valencia et al., 2023; Warsiyah et al., 2025). The gap is the operational integration of these strands into one transparent nonformal training model.

This study responds through the L-E-A-D model training. The acronym is standardized as Local Ecology, Education, Action, and Development. Local Ecology maps household waste, environmental risks, existing assets, and participant needs. Education uses dialogue, demonstration, reflection, and peer learning. Action provides supervised practice in sorting, composting, recycling, waste-bank administration, and environmental communication. Development focuses on community agency, institutional continuity, partnerships, and feasible circular enterprise activities.

The study had three objectives: (1) to identify the socio-ecological conditions and learning needs of community participants; (2) to develop and obtain expert appraisal of the L-E-A-D model and its measurement instrument; and (3) to examine preliminary short-term pretest-posttest changes after model implementation. The contribution lies in operationalizing socio-ecological andragogy as a four-stage community training sequence. Because the evaluation used one group only, the study assesses preliminary change and model feasibility; it does not test causal effectiveness.

METHODS

This study used a multi-stage research and development approach to produce and conduct a limited evaluation of the L-E-A-D training model. The process comprised: (1) qualitative exploration of local needs; (2) model and instrument development followed by expert review; and (3) a field implementation evaluated with a one-group pretest-posttest design. The third phase is pre-experimental, not quasi-experimental, because it contains neither random assignment nor a comparison group. Development procedures drew on iterative analysis, design, development, implementation, and evaluation principles (Crompton et al., 2023; Taherdoost, 2024).

The needs assessment used observation, semi-structured interviews, document review, and group discussion to examine household waste practices, waste-bank operations, learning needs, local assets, and barriers to participation. The qualitative material was organized by source and topic, compared across sources, and used to define the content, sequence, facilitation roles, and expected outputs of the prototype. Triangulation involved comparing observations with accounts from waste-bank managers and community participants.

The field phase took place at the Mugarsari Waste Bank, Mugarsari Village, Tamansari District, Tasikmalaya City. Thirty adults were recruited purposively because of their involvement in community activities or household environmental management. The supplied manuscript identifies most participants as women aged 35-60 years, but it does not provide a complete recruitment pool, participant profile, inclusion and exclusion criteria, attrition record, or final implementation dates.

The intervention followed four sequential components. Local Ecology used observation and participatory mapping to identify waste streams, risks, assets, and learning priorities. Education used facilitated discussion, demonstration, simulation, and reflection to address the 3R principles, circular economy concepts, sorting, processing, and waste-bank management. Action involved supervised practice in sorting, composting, recycling, administration, and environmental communication. Development focused on institutional roles, partnerships, product or service feasibility, and plans for continued community action. The number of sessions, session duration, trainer qualifications, attendance, materials, and fidelity procedures must be reported from implementation records.

The outcome measure contained 20 items across four domains: green knowledge, green attitudes, green skills, and circular economy agency. Scores were reported on a 0-100 scale. The source file does not identify the response format, scoring key, domain allocation, pilot sample, content-validity index, construct evidence, or reliability coefficient. These details are necessary to determine whether score changes reflect the intended constructs rather than measurement error.

Model and Instrument Validation

The prototype and outcome measure were reviewed before field implementation. Expert review should report the number and disciplinary profile of reviewers, validation criteria, rating scale, decision rule, quantitative indices, qualitative recommendations, and revisions made. The supplied file states that an expert FGD occurred but contains none of these results.

Because the available study record does not contain numerical expert-review indices or item-level psychometric evidence, the prototype is reported as an author-developed training model and the 20-item outcome measure is treated as a study-specific measure. Accordingly, the findings are interpreted descriptively and as preliminary within-group evidence rather than as validation of a standardized instrument.

Quantitative Analysis

Pretest and posttest scores were summarized with means and paired differences. Normalized gain was calculated as $(\text{posttest mean} - \text{pretest mean}) / (100 - \text{pretest mean})$. A paired-samples t test assessed whether the mean within-participant difference differed from zero. Effect sizes and confidence intervals were reported alongside significance tests, and interpretation was kept proportional to the one-group design (Lakens, 2022; Skvarc & Fuller-Tyszkiewicz, 2024). Based on $n = 30$, the reported mean difference of 27.63, and $t = 62.70$, the standard deviation of paired differences was reconstructed as 2.41; the 95% confidence interval was 26.73 to 28.53; and Cohen's d_z was 11.45. The quantitative interpretation is restricted to the reported summary statistics. The paired-test result and reconstructed effect-size statistics should therefore be read cautiously because participant-level assumption checks and the original statistical output were not available in the study record used for this manuscript.

RESULTS AND DISCUSSION

Socio-Ecological Needs Analysis

Observation and interviews indicated that the waste bank emerged in response to household waste burning and unmanaged disposal. Managers had introduced sorting, composting, and the sale of selected inorganic materials. These practices provided an institutional base for circular activity, but their reach across households remained uneven. Three operational gaps were consistent across the available qualitative accounts. First, knowledge and practice were concentrated among waste-bank managers. Second, some households continued to mix organic and inorganic waste. Third, routine participation and value-adding activities had not yet spread evenly across neighborhood units. These findings show a difference between the existence of a waste-bank institution and the wider adoption of circular practices. The needs assessment identified four linked training priorities: place-based environmental awareness; accessible education on sorting, processing, and circular value; supervised practice; and stronger community organization for continued action. These priorities became the four components of the L-E-A-D model training.

Development and Syntax of the L-E-A-D Model Training

The model starts from a local problem rather than a predetermined lecture. Local Ecology makes the environmental and social setting visible. Education connects those conditions with green knowledge, attitudes, and practical techniques. Action converts learning into observable waste-management tasks. Development consolidates roles, partnerships, and feasible economic or institutional follow-up. The sequence treats adult participants as contributors of experience and local knowledge, not only as recipients of information.

Table 1. Syntax of the Standardized L-E-A-D Training Model

Stages	Focus	Main Activities	Output
Local Ecology (L)	Place-based diagnosis	Observe waste streams; map risks, assets, actors, and learning needs; discuss prior experience	Shared map of local problems, assets, and priorities
Education (E)	Green competence	Discuss and demonstrate 3R principles, circular economy, sorting, processing, safety, and waste-bank management	Stronger green knowledge, attitudes, and task understanding
Action (A)	Supervised application	Practice sorting, composting, recycling, administration, and environmental communication	Demonstrated skills and documented community action
Development (D)	Agency and continuity	Clarify roles; develop partnerships, follow-up plans, and feasible circular products or services	Community agency, institutional continuity, and enterprise options

Source: Model development results, 2026

Local Ecology grounds learning in household routines, visible waste streams, local risks, and existing assets. This place-based diagnosis matters because sustainability competence involves interpreting systems, anticipating consequences, and acting on problems that learners recognize (Bianchi et al., 2022; Fuchs, 2024). Education then uses participants' experience, dialogue, demonstration, and reflection. Such conditions align with evidence that adult participation improves when learning is relevant, accessible, and supported by the local socio-spatial environment (Broek et al., 2024).

Action provides repeated practice rather than assuming that information will produce behavior. Participants apply sorting, composting, recycling, administration, and communication skills within the waste-bank setting. Development extends the sequence toward community agency, including continued roles, partnerships, and feasible circular products or services. This final component is important because a circular transition depends on social organization and institutional support as well as individual competence (Jaeger-Erben et al., 2021; Pambudi et al., 2025).

The model assigns complementary roles to the community, waste-bank managers, village government, technical agencies, and the university. This arrangement reflects the socio-ecological premise that household practice sits within organizational, policy, market, and environmental systems. Recent Indonesian research similarly identifies collaboration and community learning as central to resilient waste governance (Gerassimidou et al., 2025; Suryawan & Lee, 2025; Ulhasanah et al., 2025).

Expert Validation of the Model and Instrument

The prototype was refined through the development process before field implementation. Because numerical expert-validation indices and item-level instrument-validation records were not available in the study record, no unsupported validity coefficient is reported. The model is therefore presented as a development-stage training framework whose feasibility and measurement properties require further independent evaluation.

Preliminary Pretest-Posttest Findings

All four-domain means were higher at posttest than at pretest for the 30 participants. Table 2 reports the available means and paired differences. Pretest and posttest standard deviations were not included in the supplied statistical summary and therefore cannot be reported without the raw data or original software output.

Table 2. Descriptive Pretest and Posttest Results

Dimension	Pretest M	Posttest M	Mean difference
Green knowledge	56.80	89.40	32.60
Green attitudes	60.20	87.50	27.30
Green skills	57.10	85.20	28.10
Circular economy agency	60.30	82.80	22.50
Overall	58.60	86.23	27.63

Source: Reported research summary, 2026

Green knowledge showed the largest mean change (32.60 points), followed by green skills (28.10), green attitudes (27.30), and circular economy agency (22.50). These descriptive results indicate that immediately assessed knowledge changed more than the broader agency outcome. The pattern is plausible because enterprise capability, institutional coordination, and continued household practice require time beyond a short training period. Normalized gain was recalculated from each displayed mean using a maximum score of 100 (Table 3).

Table 3. Recalculated Normalized Gain

Dimension	Normalized gain	Descriptive category
Green knowledge	0.755	High
Green attitudes	0.686	Moderate
Green skills	0.655	Moderate
Circular economy agency	0.567	Moderate
Overall	0.667	Moderate

Source: Recalculated from displayed means, 2026

The recalculated overall normalized gain was 0.667, not 0.687. Domain values were 0.755 for green knowledge, 0.686 for green attitudes, 0.655 for green skills, and 0.567 for circular economy agency. Normalized gain describes improvement relative to the available score range; it does not control for testing effects, maturation, regression to the mean, or external influences. The paired samples result and statistics reconstructed from the reported values are presented in Table 4.

Table 4. Paired-Samples Statistics Based on the Reported Summary

Statistic	Value
Pretest mean	58.60
Pretest SD	Not available in supplied output
Posttest mean	86.23
Posttest SD	Not available in supplied output
Mean paired difference	27.63
SD of paired differences	2.41 (reconstructed)
95% CI for mean difference	[26.73, 28.53] (reconstructed)
Paired test	$t(29) = 62.70, p < .001$

Statistic	Value
Cohen's dz	11.45 (reconstructed; verify)
Analytic caution	Raw data and assumption checks required

Source: Reported values and transparent reconstruction, 2026

The reported test yielded $t(29) = 62.70$, $p < .001$. From the same summary values, the paired-difference SD was 2.41, the 95% confidence interval for the mean difference was [26.73, 28.53], and Cohen's dz was 11.45. This effect size is exceptionally large and should be checked against participant-level data and software output. Statistical significance shows that the observed paired scores differed within this sample; it does not establish that the training caused the difference.

Interpretation in Relation to Green Skills and Adult Learning

The strongest descriptive change occurred in green knowledge. The model explicitly combined local problem mapping with explanations, demonstrations, and practice, which may have made waste categories and circular concepts easier to understand. Sustainability competence frameworks support this integration of knowledge, values, systems thinking, and action (Akinsemolu & Onyeaka, 2025; Bianchi et al., 2022). However, the current design cannot separate the training contribution from pretest sensitization or other concurrent influences.

Changes in attitudes and reported skills are consistent with the practical and participatory structure of the model. Adult learning is more relevant when participants can connect new ideas to prior experience and immediate tasks (Broek et al., 2024; Setiawati & Shofwan, 2023). The finding should still be treated as short-term because the study did not use independent performance assessment, observation after training, or follow-up measurement. Circular economy agency showed the smallest gain. This domain involves more than individual knowledge. It depends on market access, product quality, roles, governance, infrastructure, and sustained participation. Indonesian studies confirm that circular waste management requires interaction among social, institutional, technical, economic, and environmental dimensions (Pambudi et al., 2025; Wikurendra et al., 2024). A longer evaluation is needed to examine continued sorting, enterprise activity, income, and institutional continuity. The agency dimension also needs to be interpreted within wider livelihood and governance conditions.

Research on informal waste workers shows that environmental contribution can coexist with income insecurity, occupational risk, unequal bargaining power, and limited social protection (Al Furqan et al., 2026; Costa de Castro et al., 2026; Rani et al., 2025). Social networks and trust can support cooperation, but they do not replace fair institutional arrangements (Handoyo et al., 2023; Valencia et al., 2023; Zhou et al., 2022). Accordingly, the Development stage should connect training with partnerships, transparent waste-bank management, market information, and access to relevant public services.

Interpretation of the L-E-A-D Training Model Process

Local Ecology makes the training responsive to actual household and waste-bank conditions. This function distinguishes the model from a generic awareness session because participants identify the problem, available resources, and constraints before instruction begins. It also provides a concrete basis for tailoring examples and practice. Education and Action form the central learning cycle. Facilitated dialogue makes room for experience and local knowledge, while demonstration and supervised practice provide immediate application. The approach is consistent with community-based andragogy that links participation, practical learning, and local ownership (Tan & Muangasame, 2025).

Development directs attention to what happens after the training event. Partnership roles, waste-bank routines, and feasible value-creation activities are necessary if initial competence is to become sustained

community practice. Similar nonformal learning research shows that active, interactive, product-oriented design can support entrepreneurial capability, although outcomes require continued facilitation and evaluation (Ilyas et al., 2025). This emphasis is consistent with recent JoNE evidence that mentoring, project-based learning, community learning services, and entrepreneurial competence are strengthened when programs connect practical activity with continued facilitation and institutional support (Ambarini et al., 2025; Firdaus et al., 2026; Hayat et al., 2026; Hidayat et al., 2026; Ilyas et al., 2025). Heryanto Susilo et al. (2026) further show, in a waste-worker context, that learning embedded in daily work and community interaction can reinforce responsibility, cooperation, adaptability, and environmental awareness; for the present model, these findings support recognizing participants' existing experiential knowledge rather than treating them as passive recipients. A stronger test should use a concurrent comparison group, transparent allocation procedures, validated outcome measures, intervention-fidelity records, and follow-up observations. The statistical analysis should report assumptions, missing data, confidence intervals, and effect sizes transparently (Lakens, 2022; Skvarc & Fuller-Tyszkiewicz, 2024).

LIMITATIONS

The field test used a single purposively recruited group of 30 participants from one waste bank. Without a comparison group, changes may reflect testing, maturation, history, regression to the mean, expectancy, or other influences. The study assessed outcomes immediately after training, so it cannot establish persistence, transfer to household behavior, enterprise performance, income change, or institutional sustainability. Measurement reporting is also incomplete. The supplied file does not contain expert-validation scores, item-level validity evidence, reliability coefficients, pretest and posttest SDs, assumption checks, missing-data information, or raw paired scores. The exceptionally large, reported t value and reconstructed effect size require independent verification. These limitations restrict interpretation to preliminary short-term within-group improvement.

CONCLUSION

This study developed a socio-ecological L-E-A-D training model organized as Local Ecology, Education, Action, and Development. The sequence links participatory diagnosis, adult learning, supervised waste-management practice, and planning for continued community agency. Needs assessment at the Mугarsari Waste Bank indicated that existing circular practices remained concentrated among managers and had not spread evenly across households. Among 30 participants, the overall mean increased from 58.60 to 86.23. The recalculated normalized gain was 0.667, and the reported paired test was $t(29) = 62.70$, $p < .001$. These results indicate preliminary short-term improvement within the observed group. They do not justify a causal claim because the study lacked a control group, randomization, long-term follow-up, and fully reported validation evidence. Future research should verify the statistical output, complete instrument validation, include a comparison condition, assess observed behavior and economic outcomes, and evaluate whether changes persist across communities and time.

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