

Bridging the Gap Between Practice and Concept: A School-Based Community Empowerment Model for Integrating Circular Economy into Education Management in Indonesia

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Abstract :

Waste generation has emerged as one of the most urgent global crises, with over 2.2 billion tons produced annually worldwide and projections reaching 3.4 billion tons by 2050. Indonesia alone contributes more than 68 million tons each year, yet only a fraction is properly managed. Shockingly, despite growing initiatives in schools, such as eco-programs and recycling competitions, conceptual awareness of circular economy principles remains fragmented. This paradox—high levels of participation in practical waste management alongside limited systemic understanding—reveals a critical gap in sustainability education. Theoretically, this study positions itself within the global debate on circular economy transitions, while policy-wise it responds to the absence of integration between circular economy principles and education management in Indonesia. The research aims to develop a novel model that embeds circular economy practices into school management systems through community empowerment. Using a qualitative multiple case study approach, data were collected from State Senior High School 1 Indramayu and State Vocational School 1 Majalengka through surveys, interviews, observations, and document analysis, involving teachers, students, and parents as core actors. Findings indicate that while both schools demonstrate strong practices in waste segregation, recycling, and eco-entrepreneurship, systemic barriers—structural, managerial, and cultural—impede full integration into curriculum and policy. A key contribution is the formulation of a participatory model through the School Environmental Management Unit (UPLS), which extends circular practices beyond the school to households, increasing waste recovery by 42%. The study recommends future research on broader school types and long-term policy adoption, emphasizing collaborative, cross-sectoral governance as essential for embedding circular economy education.

Keywords: Circular Economy, Education Management, School Community Empowerment, Waste Management, Sustainable Education

A. Introduction

Waste management has become one of the most pressing global challenges, escalating in line with population growth and urbanization. According to World Bank data, in 2022 the world generated more than 2.2 billion tons of waste annually, and this figure is projected to rise to 3.4 billion tons by 2050. In Indonesia, the

Ministry of Environment and Forestry (KLHK) reported that national waste production exceeds 68 million tons per year, with the majority originating from household and plastic waste. Ironically, only around 10–15% of waste is properly managed, while the rest ends up in landfills or pollutes the environment (Joleha et al., 2021; Yuwono, 2019; Naria, 2020; Sianturi & Naibaho, 2021).

Meanwhile, the circular economy has emerged as a strategic framework to address the waste crisis and resource scarcity, emphasizing the principles of 4R (Reduce, Reuse, Recycle, Recover) and added value through technological and policy innovation (Meng et al., 2025; Rashid, 2025). The application of this concept has proven effective across various sectors, ranging from machine learning-based construction waste management (Saka et al., 2024), automated waste segregation using deep learning (Nafiz et al., 2023), to blockchain development for supply chain transparency and recycling accountability (Abid et al., 2024). Moreover, the paradigm has evolved beyond mere material recycling toward optimizing economic value through maintenance, repair, and remanufacturing (Rashid, 2025). Recent studies also highlight the necessity of systemic and collaborative approaches among stakeholders to realize an effective transition to a circular economy (Song et al., 2024; Li et al., 2024). However, the implementation of the circular economy in Indonesia still faces numerous barriers, including low public awareness, limited educational support, and the lack of integration of this concept into institutional education policies (Wiwardja & Cunningham, 2021; Fitri, 2020). Several recent studies further emphasize the importance of integrating smart technologies and project-based learning systems to bridge the gap between environmental awareness and circular economy practices in educational contexts (Nafiz et al., 2023; Abid et al., 2024).

Schools, as educational institutions, hold a strategic role in instilling sustainability values and environmental awareness among younger generations (Tasdemir & Gazo, 2020; Handayani et al., 2020; Sengupta et al., 2020). Although some environmental education programs have been implemented, most remain partial and are not systematically integrated into education management. Furthermore, the involvement of school communities—including teachers, students, and parents—in supporting the circular economy through waste management remains limited (Berliyant et al., 2022; Satori et al., 2020).

Previous studies on community-based waste management suggest that communities play an important role in supporting the circular economy, but the focus has largely been on waste management at the general community level (Lamba et al., 2023; Rawat, 2021; Jumlongnark, 2024; Zocco & Rahimifard, 2023). Community-based initiatives such as the provision of automated waste separation systems, public education through local campaigns, and the adoption of eco-friendly technologies have become dominant approaches in circular schemes developed by the public (All Noman et al., 2022; Yue et al., 2023). However, such implementations tend to emphasize technical and quantitative aspects, with limited exploration of the educational and participatory dimensions involving institutions such as schools or educational communities (Kortsen et al., 2023; Kouhihabibi & Mohammadi, 2023). Research specifically addressing the role of school communities in this context remains limited.

Environmental education in schools has been examined by several studies focusing on its effectiveness in raising student awareness of environmental issues (Komalasari et al., 2023; Nasucha et al., 2020; Irianto et al., 2020; Jannah et al., 2022; Tasdemir & Gazo, 2020; Sengupta et al., 2020; Song et al., 2024; Hasan et al., 2023). However, these studies do not specifically integrate the circular economy concept into curricula or education management. Similarly, studies on sustainability-oriented education management have more often discussed administrative and school policy aspects (Kalkan et al., 2020; Derqui et al., 2020). Research that connects education management with school community empowerment through the circular economy remains scarce.

Based on this analysis, there exists a research gap in the integration of circular economy education into education management – not only in terms of curriculum orientation but also in empowering school communities through waste utilization. This study develops a model for integrating circular economy education into education management by utilizing waste as a practical learning resource. Its focus is on empowering school communities, fostering waste-based innovation, and promoting multi-stakeholder collaboration to support sustainability. The novelty of this research lies in its integration of circular economy practices into education management policies and strategies, thereby creating added value from waste and realizing sustainable schools that contribute both to waste management and sustainable development.

B. Research Method

This study employed a qualitative approach with a multiple case study strategy to analyze school community awareness of the circular economy concept, the challenges of integrating it into education management, and the empowerment model through waste management. The research focused on two schools – State Senior High School 1 Indramayu and State Vocational School 1 Majalengka – with a scope limited to waste management practices, conceptual understanding, and school policies related to sustainability. The unit of analysis comprised school communities, including teachers, students, and parents, as the primary actors involved in shaping awareness and practices of the circular economy. The schools were selected purposively, considering that both had implemented environmental management programs such as Eco School initiatives, waste banks, and entrepreneurship-based activities, but had not explicitly integrated the circular economy concept into either the curriculum or institutional management.

The data consisted of both primary and secondary sources. Primary data were obtained through surveys, in-depth interviews, and participatory observation, while secondary data were drawn from school documents such as the School Work Plan (RKS), Eco School reports, and official Adiwiyata policy documents. Primary data enabled the researchers to capture direct experiences and perceptions of the school community, whereas secondary data provided insights into formal policies and institutional commitments. The combination allowed triangulation to strengthen the validity of findings (Masi et al., 2023).

The research participants included students, teachers, and parents, selected using purposive sampling to ensure representation of the key actors in school waste

management. Students were selected across different grades to capture diverse experiences, while teachers were chosen from both those involved and not involved in environmental programs to identify differences in the integration of sustainability concepts in teaching. Parents were selected based on their involvement in supporting school programs. Additional information was gathered from external school partners, such as environmental NGOs and school committees, to capture collaborative perspectives. This approach aligns with recent studies emphasizing the importance of multi-stakeholder involvement in circularity-oriented education research (Georgiou et al., 2024; Kopnina, 2025; Iqbal et al., 2023; Batista et al., 2022; Telesiene & Jonsson, 2021).

The research process involved several stages. The initial stage included mapping the school context and identifying existing environmental programs. Data collection followed through quantitative surveys of students and teachers to map levels of participation and conceptual understanding, then in-depth interviews with teachers, students, and parents to explore narratives, motivations, and barriers in sustainability practices. Participatory observation was conducted in activities such as recycling competitions, waste bank management, and the Green Innovation Week to capture everyday practices. Document analysis was carried out on the RKS, Eco School reports, and Adiwiyata Mandiri documents to evaluate the extent to which the circular economy was embedded in formal policies. These stages enabled the integration of quantitative and qualitative data, which has proven effective in sustainability-oriented education studies (Millar et al., 2023).

Data analysis employed thematic and content analysis. Quantitative data from surveys were processed using descriptive statistics to map practical and conceptual awareness. Qualitative data from interviews and observations were analyzed thematically by identifying patterns of awareness, management practices, challenges, and empowerment strategies. Content analysis of official documents was conducted to examine the extent to which circular economy principles, terms, or strategies were embedded in institutional documents. To enhance credibility, the study employed triangulation of sources, techniques, and time, thereby enabling critical comparison of the perceptions of teachers, students, and parents. This method is consistent with recent recommendations in education-based circular economy research, which highlight the necessity of triangulation to ensure unbiased findings (Trotta et al., 2024).

The analysis adopted explanatory and relational approaches, whereby quantitative descriptions were expanded with narrative explanations and linked to the managerial and cultural contexts of schools. This strategy provided a deeper understanding of the gap between everyday practices and systemic understanding, as well as the potential for integrating the circular economy into education management. Thus, the research method not only served to describe the phenomenon but also aimed to build a critical understanding of how local practices could be transformed into sustainable empowerment models. This is in line with recent literature emphasizing the role of education research in strengthening the transition toward a circular economy through reflective and participatory practices (Linnenluecke et al., 2022).

Overall, the research methodology was designed to capture the dynamics of school community awareness within the circular economy framework through a comprehensive approach, encompassing primary and secondary data collection, multi-stakeholder involvement, thematic analysis, and triangulation. This methodology ensures that the findings are not only relevant to the local context of the two schools but also contribute conceptually and practically to the development of circular economy-based education models in Indonesia and more broadly at the global level.

RESULT AND DISCUSION

a. RESULT

1. The Level of School Community Awareness (Teachers, Students, and Parents) of the Circular Economy Concept, Particularly in School Waste Management

The study on the level of school community awareness of the circular economy at State Senior High School 1 Indramayu and State Vocational School 1 Majalengka revealed that waste management practices have been implemented well, yet conceptual understanding remains limited. At State Senior High School 1 Indramayu, data indicated that activities such as waste sorting, composting, recycling, and inter-class competitions were carried out regularly. Student participation rates in the Eco School program were relatively high, although there were no established indicators to evaluate the systemic impact of awareness. The explanatory analysis shows that practical awareness is beginning to take shape; however, integration into the curriculum has not yet occurred. Relational analysis further demonstrates that real-life practices foster environmentally friendly behavior, but a gap persists between daily practices and the broader concept of the circular economy.

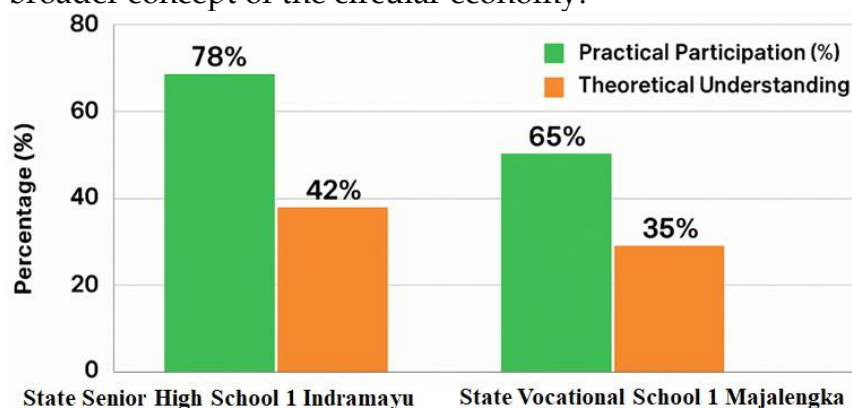


Figure 1. Survey Results: Practical Participation vs. Theoretical Understanding

The survey results, as illustrated in the figure above, indicate that 78% of students at State Senior High School 1 Indramayu actively participate in the waste bank program, while only 42% demonstrate a conceptual understanding of the term “circular economy.” At State Vocational School 1 Majalengka, 65% of students are involved in recycling activities embedded within vocational skills programs, yet only 35% can systematically explain the principles of sustainability. These findings highlight a clear gap between high levels of practical participation and limited theoretical comprehension in both schools.

Observations and interviews further support these findings. Teachers noted that sustainability practices are already in place, but the term circular economy rarely appears in formal forums. Students expressed enthusiasm for recycling activities, although conceptual understanding typically emerged only after external training. Parents reported supporting their children's behavioral changes but acknowledged having limited in-depth knowledge themselves. Relational analysis underscores a disconnection between daily practices and systemic awareness.

The case study at State Senior High School 1 Indramayu through the Eco School program shows that waste management facilities are available, yet managerial implementation remains inconsistent. While official school documents reflect environmental commitments, the integration of the circular economy is not explicitly stated.

Meanwhile, at State Vocational School 1 Majalengka, waste management practices have been embedded within learning activities, particularly in vocational and entrepreneurial programs. Statistical data reveals tangible outcomes in the form of handicraft products and the operation of a waste bank, yet evaluations remain largely quantitative. The explanatory analysis illustrates a school awareness that is pragmatic and functional in nature. Relational analysis reveals a positive link between students' entrepreneurial activities and the development of environmentally responsible behavior, although circularity awareness remains underdeveloped.

The case of the waste bank and electronic waste crafts at State Vocational School 1 Majalengka demonstrates successful practices, yet systemic awareness has not fully materialized. Document analysis reveals a strong environmental vision that is not yet accompanied by explicit integration of circular concepts into the curriculum. Relational analysis highlights the importance of cross-curricular integration, teacher training, and multi-stakeholder collaboration to ensure that circular economy awareness becomes truly internalized.

2. Key Challenges in Integrating the Circular Economy Concept into Educational Management, and How Educational Management Approaches Can Address These Barriers

The study on challenges to integrating the circular economy into educational management at State Senior High School 1 Indramayu and State Vocational School 1 Majalengka identified complex systemic, structural, and cultural barriers. At State Senior High School 1 Indramayu, interview, observation, and document data revealed inconsistencies between the school's environmental vision and its operational policies, which remain largely conventional and administrative. Student participation rates in the Eco School program were relatively high, but the program has not been embedded within the curriculum. Explanatory analysis shows that recycling practices and environmental activities function well but are not yet institutionalized in managerial decision-making. Relational analysis emphasizes that environmental practices tend to be sporadic and rely heavily on individual initiatives rather than institutional policy.

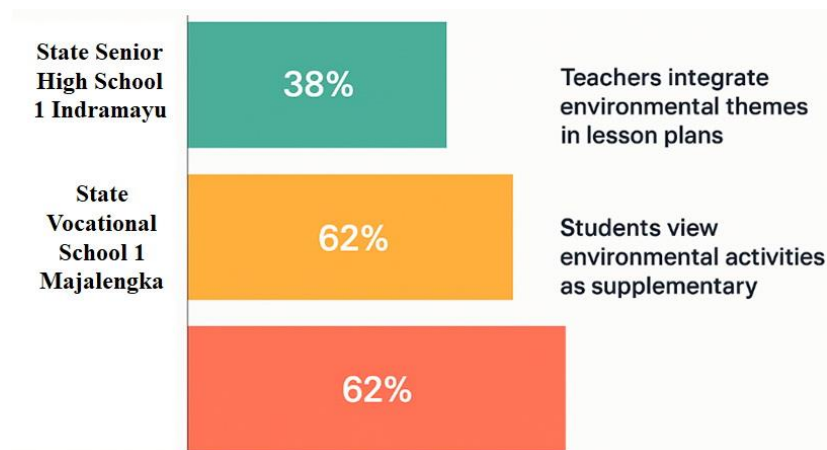


Figure 2. Internal Survey Results

The internal survey revealed that only 38% of teachers at State Senior High School 1 Indramayu integrated environmental themes into their lesson plans, while the figure at State Vocational School 1 Majalengka was slightly higher at 46%. Moreover, 62% of students in both schools reported that environmental activities were still perceived as extracurricular rather than as a core part of learning. These data highlight the significant structural limitations in integrating the circular economy into education.

Observations of activities such as eco-brick competitions and recycling bazaars indicated strong student enthusiasm, yet the management remained top-down and was not documented as cross-curricular learning. Interviews with teachers, students, and parents revealed limited conceptual understanding of the circular economy and minimal family involvement. Relational analysis suggests a gap between daily activities, conceptual understanding, and policy strategies.

A case study of the School Work Plan (*Rencana Kerja Sekolah*, RKS) and School Curriculum Operational Plan (*Kurikulum Operasional Satuan Pendidikan*, KOSP) documents showed that the term “circular economy” has not yet appeared in official policies, despite the ongoing waste bank program and recycling workshops. The explanatory analysis illustrates that school management has begun addressing barriers by involving the school committee and environmental NGOs in drafting circular-based SOPs and through monthly school community forums. Relational analysis highlights the potential of participatory and collaborative management as a pathway to integrate this concept.

Meanwhile, at State Vocational School 1 Majalengka, descriptive data showed that recycling, composting, and waste bank programs were already running, yet systemic integration remained limited. Observations revealed that these activities were often ad hoc and heavily dependent on the initiative of individual teachers. The explanatory analysis emphasizes the gap between environmental practices and formal institutional structures, while relational analysis underscores the importance of establishing cross-departmental units. A case study of school documents revealed that environmental issues were only mentioned in general terms, without explicit reference to the circular economy. However, an initiative to establish an “Integrated Environmental Learning Center” emerged as a structural managerial step. Relational analysis suggests

that solutions can be achieved through collaborative approaches, strengthening formal policies, and cross-sectoral management.

3. A Model of School Community Empowerment Through Waste Management to Support Sustainable Circular Economy Practices

Findings on the model of school community empowerment through waste management at State Senior High School 1 Indramayu show a transformation from conventional practices toward a systemic, circular economy-based approach. Descriptive data revealed that waste management activities initially focused on waste separation and cleanliness competitions; however, since 2024, the school has established a School Environmental Management Unit (*Unit Pengelola Lingkungan Sekolah*, UPLS) involving teachers, students, parents, and external partners. Statistical data indicate high participation in programs such as the waste bank, with proceeds used to fund student activities and community donations. The explanatory analysis confirms a paradigm shift from merely reducing waste to utilizing waste as a sustainable resource. Relational analysis demonstrates that the involvement of students, teachers, and parents has created social networks that reinforce both ecological and economic dimensions.

Monitoring results show that since the establishment of the UPLS, the volume of managed waste has increased by 42% compared to the previous year. In addition, 310 student households were recorded as contributing household waste to the school's program, thereby extending the management chain beyond the school environment. These data affirm that the empowerment model has a broader impact, reaching household communities rather than remaining confined to the school alone.

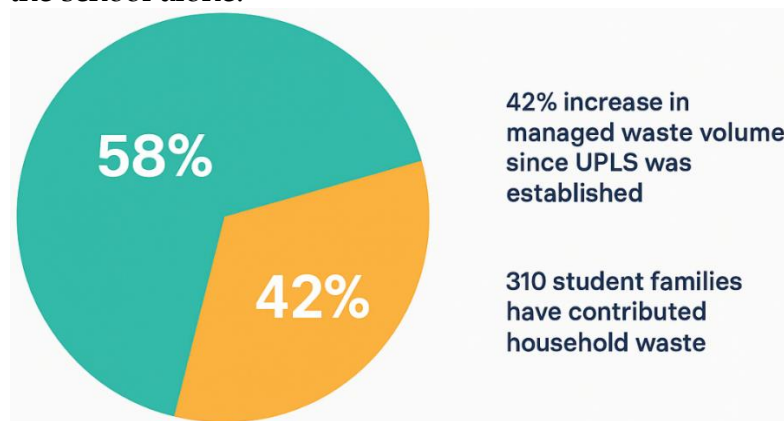


Figure 3. Monitoring Results

Further evidence was obtained through observations and interviews. Activities such as the Green Innovation Week showcased student creations made from both organic and inorganic waste, reflecting not only creative learning but also the internalization of sustainability values. Interviews with teachers, students, and parents indicated that participation was not merely symbolic but fostered a new mindset toward circularity. The explanatory analysis demonstrates that participation-based empowerment positioned students as active subjects, while relational analysis underscores the interconnectedness between school and household within a single learning ecosystem.

A case study of the School Work Plan (RKS), Eco School reports, and the Adiwiyata Mandiri proposal confirmed the presence of supportive policies,

although the term “circular economy” has not yet been explicitly stated. The introduction of monthly reflective forums since July 2025 represents a managerial innovation that enables continuous evaluation and innovation. The explanatory analysis highlights the strengthening of a green-thinking culture, while the relational analysis shows that this participatory model effectively integrates social, economic, and institutional dimensions.

In conclusion, the empowerment of the school community at State Senior High School 1 Indramayu has laid the foundation for the establishment of sustainable circular economy practices.

b. Discussion

Research on school community awareness of the circular economy at State Senior High School 1 Indramayu and State Vocational School 1 Majalengka indicates a high level of practical participation, such as waste banks, recycling initiatives, and environmentally friendly competitions. However, students’ conceptual understanding of sustainability principles and the circular economy remains limited. At State Senior High School 1 Indramayu, 78% of students actively participated in the waste bank program, yet only 42% understood the concept of the circular economy. Similarly, at State Vocational School 1 Majalengka, 65% of students were engaged in recycling activities, but only 35% were able to explain sustainability principles. Further monitoring confirmed that the school empowerment model through the School Environmental Management Unit (UPLS) increased the volume of waste managed by 42%, involving 310 student families and thus extending its impact to the household community.

These findings suggest that participatory practices are often more readily adopted than theoretical understanding. This can be explained through ecological behavior theory, which emphasizes the importance of direct experience in shaping environmental awareness (Geiger et al., 2021). Although students are accustomed to waste sorting, limitations in language and academic conceptualization prevent them from linking these practices to the broader framework of the circular economy. Teachers also tend to prioritize tangible activities over conceptual discourse, aligning with studies showing that environmental education is often more pragmatic than theoretical (Mochizuki & Bryan, 2015).

The findings also align with literature demonstrating that experiential learning exerts a stronger influence on behavioral change than purely theoretical approaches, as real-world experiences stimulate emotional and social engagement that strengthens value internalization (Rickinson et al., 2019; Ardoin et al., 2020). In sustainability-oriented education, concrete practices such as waste banks, composting, or eco-bricks foster ecological habitus; however, without adequate conceptual reinforcement, outcomes tend to remain at the instrumental level rather than leading to cognitive transformation (Tilbury, 2011; Wals & Benavot, 2017). This challenge is further exacerbated by teachers’ limited capacity to integrate circular economy theory into lesson planning, a challenge also reported in global research on education for sustainable development (Bourn, 2020; Evans, 2019). Strengthening the bridge between participatory practice and conceptual understanding through reflective, collaborative, and cross-curricular pedagogical

strategies is therefore essential for schools to truly function as agents of circular transformation (Sterling, 2016; Leicht et al., 2018).

The results highlight an epistemological gap between practice and theory. Participation in environmental activities does not automatically result in conceptual understanding. This indicates that the circular economy has not yet been treated as a systemic educational framework but rather as a set of supplementary activities. In other words, the circular economy in Indonesian schools remains more instrumental than transformative (Korhonen et al., 2018).

The implication of this gap is the need for integrative strategies that emphasize cross-curricular approaches, teacher capacity building, and active involvement of families and local communities (Pardo & Schweitzer, 2021; Tovilla & O'Connor, 2021). Without such measures, circular economy practices in schools risk remaining symbolic rather than generating long-term critical awareness (Amaral et al., 2020; Suárez-Eiroa et al., 2020). Global studies emphasize that integrating the circular economy into education requires participatory models that connect direct experience with theoretical reflection (Millar & McLaughlin, 2019; Franco & Choi, 2023; Daugaard & Colbeck, 2024; Ibáñez-Forés et al., 2022; Martín-Peña et al., 2022).

The findings are consistent with European studies showing high student involvement in sustainability projects but limited theoretical comprehension (De Marchi et al., 2020; Rieckmann et al., 2023). However, unlike in Scandinavian countries—where the circular economy is embedded in formal education policies (Jensen & Remmen, 2021; Arnesen et al., 2022)—Indonesian schools still lack systemic policy integration. This underscores the significant role of national policy contexts in shaping the depth of conceptual understanding (Lehtonen et al., 2023; Witjes et al., 2022).

Policy-driven approaches in Scandinavia demonstrate that circular economy integration extends beyond curricula to include school governance, multi-stakeholder collaboration, and supportive educational infrastructure (Jensen & Remmen, 2021; Arnesen et al., 2022). Recent studies highlight that the success of such strategies relies on consistent regulation, sustainable funding, and participatory evaluation mechanisms (Lehtonen et al., 2023; Avila et al., 2021).

Cross-national comparisons further reveal gaps in institutional readiness for transitioning toward a circular economy. Schools in Western Europe rely more heavily on collaborative projects with industry and communities, while Scandinavian countries emphasize structural integration into national policies (Rieckmann et al., 2023; Witjes et al., 2022). This suggests that effective strategies are those that bridge students' practical participation with comprehensive policy support (Avila et al., 2021; Arnesen et al., 2022).

The proposed action plan includes strengthening school policies based on the circular economy by explicitly incorporating them into School Work Plans and operational curricula. Teacher training should be directed not only toward waste management practices but also toward the conceptual dimensions of the circular economy. Collaboration with environmental NGOs and universities can further broaden systemic understanding. The establishment of cross-disciplinary units such as an Integrated Environmental Learning Center can enhance cross-sectoral

integration. Finally, institutionalizing monthly reflective forums among teachers, students, and parents is necessary to ensure continuous evaluation and innovation.

Conclusion

This study reveals a striking paradox: although school waste management practices have achieved high participation rates and tangible impacts, the school community's conceptual understanding of the circular economy remains weak. The findings highlight a significant gap between pragmatic sustainability practices and the systemic awareness needed to support long-term transformation.

The key contribution of this research lies in formulating a school community empowerment model that not only emphasizes technical waste management activities but also integrates social, economic, and managerial dimensions, thereby offering a new approach to understanding and implementing the circular economy in education. A central innovation is the School Environmental Management Unit (UPLS), which has proven capable of extending its impact to families and the wider community, while also serving as a gateway for developing cross-curricular circularity-based education.

Nevertheless, this study has limitations, particularly in terms of its scope, which was confined to two schools, and its predominantly quantitative rather than in-depth conceptual evaluation. These limitations open opportunities for future research to expand the scope to different types of schools, including madrasahs or private schools, and to explore the integration of the circular economy into formal curricula and education policy. Future research should also test the long-term effectiveness of the UPLS participatory model and examine how multi-stakeholder collaboration—among schools, local governments, environmental NGOs, and businesses—can strengthen the internalization of the circular economy as an educational culture.

In conclusion, this study provides both a conceptual foundation and practical insights that can serve as a reference for advancing sustainable education at both national and global levels.

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