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Strategies to Enhance Citizen Participation through Innovation in Environmental Education Programs Based on Multi-Stakeholder Collaboration and Digital Technology

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Abstract
This study aims to analyze strategies for enhancing citizen participation in environmental education through program innovations based on multi-stakeholder collaboration and the use of digital technology. The method employed is a literature review with a qualitative approach and descriptive analysis, primarily intended to enrich references related to community service in the field of environmental studies. Data were collected from scholarly articles in Google Scholar and credible websites within the period of 1977–2025. From the initial 50 articles identified, 27 were selected through a strict screening process based on relevance, quality, and contribution to the research topic. The findings reveal that enhancing citizen participation is influenced by cross-sector collaboration, innovative learning design, and the application of interactive and inclusive digital technologies. Theories such as Civic Engagement, Collaborative Governance, the Technology Acceptance Model, Self-Determination Theory, Social Learning, and Diffusion of Innovations provide relevant conceptual foundations for understanding the dynamics of participation. Case studies such as the Climate Village Program (ProKlim), Digital Waste Bank in Bandung, and Pentingsari Tourism Village in Yogyakarta provide empirical evidence of the successful implementation of these strategies. This research makes an important contribution to the development of participatory-based environmental education, strengthens multi-stakeholder collaboration, and enriches sustainable community service practices.

Keywords: Environmental Education, Citizen Participation, Innovation, Multi-Stakeholder Collaboration, Digital Technology, Community Service

Strategi Peningkatan Partisipasi Warga melalui Inovasi Program Pendidikan Lingkungan Hidup Berbasis Kolaborasi Multi-Pihak dan Teknologi Digital

Abstrak
Penelitian ini bertujuan untuk menganalisis strategi peningkatan partisipasi warga dalam pendidikan lingkungan hidup melalui inovasi program berbasis kolaborasi multi-pihak dan pemanfaatan teknologi digital. Metode yang digunakan adalah tinjauan pustaka dengan pendekatan kualitatif dan analisis deskriptif, dengan fokus utama untuk menambah referensi terkait pengabdian masyarakat di bidang lingkungan. Data diperoleh dari artikel ilmiah di Google Scholar dan website kredibel dengan rentang waktu 1977–2025. Dari 50 artikel yang diidentifikasi pada tahap awal, sebanyak 27 artikel dipilih setelah melalui seleksi ketat berdasarkan kriteria relevansi, kualitas, dan kontribusi terhadap topik penelitian. Hasil penelitian menunjukkan bahwa peningkatan partisipasi warga dipengaruhi oleh faktor kolaborasi lintas sektor, desain pembelajaran yang inovatif, serta penerapan teknologi digital yang interaktif dan inklusif. Teori Civic Engagement, Collaborative Governance, Technology Acceptance Model, Self-Determination Theory, Social Learning, dan Diffusion of Innovations menjadi landasan konseptual yang relevan dalam memahami dinamika partisipasi. Studi kasus seperti Program Kampung Iklim (ProKlim), Bank Sampah Digital di Bandung, dan Desa Wisata Pentingsari di Yogyakarta menunjukkan bukti empiris keberhasilan penerapan strategi tersebut. Penelitian ini memberikan kontribusi penting bagi pengembangan pendidikan lingkungan berbasis partisipasi,

memperkuat kolaborasi multi-pihak, dan memperkaya praktik pengabdian masyarakat yang berkelanjutan.

Kata kunci: Pendidikan Lingkungan Hidup, Partisipasi Warga, Inovasi, Kolaborasi Multi-Pihak, Teknologi Digital, Pengabdian Masyarakat

INTRODUCTION

Environmental issues today are gaining increasing global attention due to the escalation of problems such as climate change, pollution, declining water and air quality, and suboptimal waste management, all of which directly affect human sustainability. Environmental education serves as one of the key instruments to address these challenges, as it enhances public awareness, understanding, and behavior in preserving the environment sustainably. However, various studies indicate that the success of environmental education is not determined solely by the quality of the learning content but also by the extent to which citizens actively participate in the process (Mintoff et al., 2024; Phuangsuwan et al., 2025). Citizen participation is crucial as it enables collective behavioral change at individual, family, and community levels. In this context, strategies to increase participation must be directed toward more innovative approaches, relevant to community needs, and based on principles of collaboration as well as the use of digital technologies that are increasingly embedded in daily life.

The literature highlights that community participation in environmental education programs often faces challenges such as low motivation, limited technical knowledge, restricted access to information, and a lack of sense of ownership toward the programs implemented (Dioba et al., 2024; Ward et al., 2018). Effective environmental education programs must encourage active community engagement through participatory mechanisms that accommodate aspirations, needs, and local potential. This concept aligns with Freire's (2005) critical pedagogy, which emphasizes that education should be dialogical, liberating, and empowering, enabling communities to become subjects of social change. Thus, citizen participation can be measured by involvement in the planning, implementation, evaluation, and sustainability of environmental education programs themselves.

A collaborative approach involving multiple stakeholders is a key strategy to strengthen citizen participation in environmental education. Multi-stakeholder collaboration encompasses the involvement of government, educational institutions, civil society organizations, the private sector, and local communities, each contributing distinct roles and resources. According to the Collaborative Governance theory proposed by Ansell and Gash (2008), the success of collaboration depends on face-to-face dialogue, trust-building, commitment to shared processes, and mutual understanding of common goals. In the context of environmental education, such collaboration enables resource exchange, expertise sharing, and wider networks, thereby making programs more impactful, scalable, and sustainable. Moreover, collaboration fosters a sense of collective responsibility, thus reinforcing citizen participation with more systematic support.

Meanwhile, the development of digital technology creates new opportunities to enhance public participation in environmental education programs. Digital platforms such as social media, online learning applications, virtual discussion forums, and community-based information systems can be utilized as tools for communication, education, and environmental advocacy. According to Davis (1989) in the Technology Acceptance Model (TAM), the adoption of technology by society is strongly influenced by perceived ease of use and perceived usefulness. In this regard, digital technology can broaden access to environmental information, improve ecological literacy, and facilitate citizen interaction without spatial or temporal limitations. For example, the use of smartphone-based environmental reporting applications enables communities to easily report pollution or waste problems in their surroundings, while simultaneously fostering a stronger sense of involvement and environmental concern.

Innovation in environmental education programs based on digital technology also enables more interactive, creative, and engaging learning approaches. For example, the integration of gamification methods, digital simulations, or the use of multimedia content can increase community motivation to actively participate in programs. Several studies indicate that technology-based learning can enhance participant engagement, as they feel more connected to materials presented in a visual, practical, and applicable manner (Azizah, 2024; Hajj-Hassan et al., 2024). This aligns with the Self-Determination Theory proposed by Ryan and Deci (2000), which explains that an individual's involvement in an activity will be higher when driven by intrinsic factors such as curiosity, competence, and autonomy. Therefore, digital-based environmental education strategies should carefully consider learning designs that foster citizens' intrinsic motivation.

Beyond the learning aspect, the use of digital technology also broadens the space for collaboration among stakeholders in environmental education. Digital platforms can serve as coordination mediums for governments, schools, universities, civil society organizations, and the private sector in designing and implementing joint programs. Such collaboration involves resource synergy and innovation in creating tangible solutions to environmental challenges. Case studies in various countries demonstrate that the use of community-based digital platforms has successfully improved the effectiveness of environmental programs, such as digital waste bank management, application-based reforestation programs, and energy-saving movements through online campaigns (Johnson et al., 2021; Mersico et al., 2025; Redyantanu et al., 2022). Thus, digital technology serves a dual role: as a tool for education and as an instrument for collaboration.

Nevertheless, the effectiveness of strategies to enhance citizen participation through innovations in environmental education programs based on multi-stakeholder collaboration and digital technology still faces several challenges. One of the main issues is the digital divide that persists in many regions, particularly in terms of unequal access and digital literacy between urban and rural communities. Additionally, conflicting interests among stakeholders can create barriers in collaboration, requiring mediation mechanisms and transparent governance structures. Equally important is the sustainability of

programs, as many environmental education initiatives are designed as short-term projects, resulting in limited long-term impact. Therefore, more in-depth research on strategies to increase citizen participation is necessary to identify the most suitable formula for ensuring that innovations in environmental education are inclusive, adaptive, and sustainable.

Based on this literature review, it can be concluded that strategies to enhance citizen participation in environmental education require the integration of innovative learning, multi-stakeholder collaboration, and the participatory and sustainable use of digital technology. Environmental education must encourage citizens' active involvement in the process of collective behavioral change toward sustainability. With the support of digital technology, participation can be expanded through online interactions, easier access to information, and more interactive learning innovations. Meanwhile, multi-stakeholder collaboration strengthens the legitimacy, effectiveness, and sustainability of programs. Therefore, this study aims to analyze the most effective strategies for enhancing citizen participation through innovative environmental education programs based on multi-stakeholder collaboration and digital technology, thereby making a concrete contribution to the development of educational models that are adaptive to contemporary challenges.

Environmental Education

Environmental education is a learning process aimed at fostering awareness, knowledge, attitudes, skills, and behaviors that enable communities to actively participate in protecting, preserving, and managing the environment sustainably (Fang et al., 2023). This form of education focuses on cultivating critical awareness and active participation of society in seeking practical solutions. In both global and local contexts, environmental education functions as a strategic instrument to drive collective behavioral changes that are environmentally friendly, for instance, through waste management programs, energy conservation initiatives, or community-based reforestation activities. Thus, environmental education serves as a vital foundation for building empowered communities that are responsible for the sustainability of ecosystems.

Citizen Participation

Citizen participation refers to the active involvement of communities in every stage of planning, implementation, evaluation, and sustainability of development programs, including in the field of environmental education (Syamsiyah et al., 2025). The concept of participation encompasses the contribution of ideas, decision-making, and commitment to tangible actions. The level of community participation strongly determines the success of a program, as it fosters a sense of ownership while simultaneously enhancing social legitimacy. In the context of environmental education, citizen participation is reflected in activities such as tree planting, waste management, energy conservation, and community-based environmental monitoring. Therefore, strategies to strengthen participation must be designed with consideration of citizens' intrinsic motivation, local needs, and the support of relevant stakeholders.

Innovation

Innovation in environmental education is understood as the effort to create new ideas, methods, or programs that improve learning effectiveness and strengthen community involvement (Dahms et al., 2020). Innovation may take the form of digital technology utilization, gamification methods, multimedia content, or the integration of local wisdom with modern strategies. Innovation is not limited to technical aspects but also includes ways to build communication, develop more inclusive participation models, and strengthen collaboration among stakeholders. Through innovation, environmental education becomes more adaptive to social dynamics and contemporary developments, thereby becoming a transformative activity capable of fostering behavioral change among citizens in preserving the environment.

Multi-Stakeholder Collaboration

Multi-stakeholder collaboration refers to cooperation that involves diverse stakeholders such as governments, educational institutions, civil society organizations, the private sector, the media, and local communities in achieving shared objectives (Siangulube, 2024). In environmental education, multi-stakeholder collaboration plays an essential role because environmental problems are complex and require cross-sectoral contributions. Through collaboration, each actor can contribute resources, expertise, and networks, making programs more effective and sustainable. For instance, governments may provide regulations and policy support, universities may contribute scientific knowledge, the private sector may offer funding or technology, while communities serve as key implementers on the ground. Thus, multi-stakeholder collaboration becomes a strategic approach to strengthen citizen participation and create broader impacts in environmental education.

Digital Technology

Digital technology serves as a crucial instrument in strengthening environmental education because it enables more effective, rapid, and interactive communication, learning, and collaboration (Azizah, 2024). This includes the use of applications, social media, e-learning platforms, digital reporting systems, and engaging multimedia content to improve environmental literacy and awareness. The use of digital technology facilitates citizen participation in environmental activities without spatial and temporal limitations. For example, digital waste bank applications that record citizen contributions or online community platforms that promote discussion and environmental advocacy. In other words, digital technology can act as a bridge between environmental education theory and real-world practices that actively and inclusively engage communities.

Community Service

Community service represents the tangible contribution of academics, particularly universities, in empowering communities through the application of knowledge, technology, and innovation to improve collective quality of life. In the context of

environmental education, community service functions as a collaborative medium among universities, governments, and local communities to address environmental challenges through participatory programs (Vukojević Medvidović et al., 2024). Community service prioritizes empowerment by actively involving citizens in the planning, implementation, and evaluation of programs. Examples include digital marketing training for ecotourism villages, integrated waste bank programs, and community-based conservation education. Thus, community service plays a vital role in strengthening the synergy between theory, practice, and citizen empowerment, while also enriching references and models that can be replicated in various regions.

METHOD

This study employed a literature review method with a qualitative approach, focusing on the collection, analysis, and synthesis of previous research findings to gain a deeper understanding of strategies to enhance citizen participation through innovations in environmental education programs based on multi-stakeholder collaboration and digital technology. This approach was chosen because it aligns with the main objective of the research, namely to enrich references related to community service, particularly in the context of implementing environmental education programs that emphasize citizen involvement and program sustainability. By strengthening the theoretical foundation and integrating prior empirical experiences, this study is expected to provide a useful reference for community service practices relevant to environmental education issues.

The data sources used in this study were drawn from scholarly articles accessed via Google Scholar and several credible websites with strong academic and professional reputations. To maintain the relevance and currency of the data, the selected literature was limited to the period 1977–2025, as this range reflects the most recent developments in environmental education studies, multi-stakeholder collaboration, and the use of digital technology. At the initial stage, 50 articles were identified based on the research keywords. However, after a rigorous selection process applying eligibility criteria—such as topic relevance, methodological quality, relation to the context of environmental education and citizen participation, and contribution to community service—the final sample was narrowed down to 27 articles.

Data analysis was carried out using a qualitative descriptive analysis technique, which involved an in-depth reading of each article, categorizing information into key themes (citizen participation, environmental education innovation, multi-stakeholder collaboration, and the use of digital technology), and comparing findings across the literature. This process enabled the researcher to identify patterns, similarities, differences, and research gaps that still require further exploration. Therefore, the results of this study not only present a summary of the literature but also provide a more structured conceptual synthesis to strengthen the knowledge base in environmental education and, more specifically, to enrich references related to community service. The findings are expected to be useful for academics, practitioners, and stakeholders involved in designing and implementing environmental programs based on citizen participation.

FINDING AND DISCUSSION

Citizen participation in environmental education programs is a crucial aspect that determines both ecosystem sustainability and the quality of community life, since the success of environmental management depends on the willingness of society to actively engage in behavioral changes and collective action. The Civic Engagement Theory proposed by Verba et al. (1995) states that public involvement in social and environmental issues is strongly influenced by three main components: resources (the availability of means to support participation), engagement (the motivation and awareness that drive involvement), and mobilization (strategies and efforts to organize citizens to act collectively). In the context of environmental education, resources may include access to clear information, contextual learning materials, and supporting facilities such as recycling centers or community learning spaces. Motivation can be cultivated by emphasizing the tangible benefits for citizens, such as reduced electricity costs through eco-house programs or improved air quality through collective greening initiatives. Mobilization can be realized through collaborative approaches involving educational institutions, village governments, local communities, and private sector actors providing financial and technical support. A study by Cornélusse et al. (2019) confirms that citizen participation increases when there is concrete evidence of direct outcomes, such as reduced household expenses, improved environmental health, or economic value gained from waste banks. Thus, participation must be fostered through innovative strategies that connect environmental education programs with citizens' practical, everyday needs.

Multi-stakeholder collaboration emerges as a vital strategy to strengthen public participation, as environmental issues are complex and cannot be solved by a single actor alone. Ansell and Gash (2008), in their Collaborative Governance Theory, emphasize that successful collaboration depends on intensive dialogue among actors, gradually built trust, and joint commitment to achieving collective goals. In the Indonesian context, this collaborative practice is evident in the Climate Village Program (ProKlim) managed by the Ministry of Environment and Forestry, where citizens are directly involved in designing, implementing, and evaluating climate adaptation and mitigation programs. A study by Ariyaningsih and Shaw (2023) reveals that the success of ProKlim in various regions is determined by cross-sector engagement: local governments providing policy support, local communities acting as grassroots mobilizers, the private sector supplying funding or technology, and universities contributing through research and knowledge-based assistance. Such collaboration enhances legitimacy in the eyes of citizens, as they perceive the program as born from dialogue rather than top-down directives. This legitimacy becomes the key driver of active participation, as citizens develop a sense of ownership over the program. In other words, the more inclusive the collaborative process, the greater the potential for sustaining citizen participation in environmental education.

Digital transformation has had a profound impact on expanding the reach and effectiveness of environmental education, particularly since the COVID-19 pandemic accelerated the adoption of technology across multiple sectors, including both formal and non-formal education. According to the Technology Acceptance Model (TAM) developed

by Davis (1989), public acceptance of technology is influenced by two key factors: perceived usefulness (the degree to which a person believes technology provides tangible benefits) and perceived ease of use (the degree to which technology is user-friendly). In environmental education, digital applications can serve as a bridge to connect educational materials with the learning styles of younger generations who are increasingly accustomed to technological devices. Research by Prabawa-Sear (2018) in secondary schools in Yogyakarta and Surabaya found that students showed higher enthusiasm for environmental topics when delivered through interactive methods such as educational videos, app-based quizzes, online discussion forums, and virtual ecosystem management simulations. These findings suggest that digitalization is a critical instrument for enhancing engagement, as interactivity fosters more personal, engaging, and accessible learning experiences. Moreover, digital technology facilitates the mobilization of citizen participation through social media, e-learning platforms, and community-based applications that enable rapid information sharing and dissemination of best practices. Thus, the use of digital technology in environmental education serves a dual function: enhancing learning interest while simultaneously broadening citizen participation across generations and regions.

Innovation in technology-based environmental education creates significant opportunities to strengthen citizen participation through gamification, simulations, and digital reward systems that not only deliver educational messages but also generate enjoyable and motivating learning experiences. The Self-Determination Theory developed by Ryan and Deci (2000) explains that intrinsic motivation is strengthened when individuals experience three fundamental needs in an activity: competence, autonomy, and relatedness. In the context of environmental education, this approach can be applied through digital program designs that cultivate a sense of personal achievement, provide freedom in choosing modes of participation, and build connected communities working toward common goals. A concrete example can be seen in the Digital Waste Bank program in Bandung studied by Fahriza and Yuliana (2024), where an application tracks the amount of waste collected by citizens, awards points redeemable for basic necessities, and transparently displays citizen contribution rankings. This system fosters social engagement, as citizens feel part of an environmentally conscious community while also receiving recognition for their contributions. The program's success demonstrates that gamification and digital reward systems can effectively reinforce intrinsic motivation for consistent participation in environmental education and action, as individuals perceive a direct link between personal effort, tangible benefits, and collective contributions to environmental sustainability.

In addition to technology-based approaches, environmental education strategies are also highly relevant when linked to the Social Learning Theory proposed by Bandura (1977), which asserts that much of human behavior is learned through observation, imitation, and social interaction. In the context of environmental participation, citizens are more likely to be motivated to take part when they witness tangible examples from community leaders, local figures, or even neighbors who demonstrate strong commitment

to environmental conservation activities. This aligns with the concept of role models, where individual behavior can spread to others through repeated processes of observation and social learning. Research by Aini & Wulandari (2021) in Pentingsari Tourism Village, Yogyakarta, provides evidence that the success of conservation programs rooted in educational tourism is largely supported by local figures who act as role models in maintaining cleanliness, managing waste, and educating visitors about the importance of conservation. The presence of these role models creates a domino effect, as other residents feel motivated to replicate such positive behaviors both to safeguard the village's reputation and to gain social recognition. If this strategy is further supported by digital tools—for instance, by showcasing role model activities on village social media accounts or environmental community apps—the inspirational impact can reach an even wider audience. This highlights that environmental education requires role models who can act as catalysts for change at the local level.

From the perspective of community service, innovations in environmental education that integrate multi-stakeholder collaboration and digital support provide significant added value, as such approaches create shared learning spaces based on the community's real needs while strengthening aspects of empowerment. Community service is no longer perceived merely as a one-way transfer of knowledge from universities to society, but has evolved into a collaborative mechanism in which communities themselves play a central role in the creation, implementation, and evaluation of programs. Research by Kalpikawati et al. (2024) on community service in Taro Tourism Village, Bali, serves as a concrete example: digital marketing training designed to support the management of eco-tourism accommodations generated a dual impact—first, by enhancing citizens' digital skills so they could better promote tourism products and services, and second, by fostering awareness of environmental conservation as a key attraction for sustainable tourism. This type of approach provides valuable inspiration for universities, governments, and the private sector to position environmental education as a strategic agenda in community service programs. By integrating technology, local culture, and economic needs, community service in environmental education promotes the development of sustainability practices that are relevant, innovative, and long-term at the local level.

However, the implementation of environmental education through digital technology and multi-stakeholder collaboration is not without challenges. These include digital divides, conflicting interests among actors, and the sustainability of long-term programs. The Diffusion of Innovations Theory proposed by Rogers et al. (2019) explains that the adoption of innovation is influenced by five main factors: relative advantage (the degree to which an innovation is seen as better than the old methods), compatibility (its alignment with user values and needs), complexity (the difficulty of use), trialability (the extent to which it can be tested), and observability (the visibility of its benefits). In the context of digital environmental education, barriers often arise in rural or remote areas where internet access is inadequate, technological devices are limited, and digital literacy is low—making it difficult for citizens to grasp the benefits of digital applications or platforms. A study by Teguh et al. (2021) highlights the failure of some app-based

environmental reporting programs in remote Kalimantan, where weak network infrastructure and low technological competence hindered citizens' participation, causing the intended solution to instead result in exclusion. Furthermore, divergent interests among stakeholders may also undermine program sustainability—for instance, when governments prioritize short-term targets, while communities are more focused on immediate economic benefits. Therefore, inclusive strategies must be carefully designed to fit local contexts, including the provision of digital literacy training, the adaptation of technologies to meet community needs, and participatory financing models to ensure that digital innovations are accessible to wider populations without exacerbating participation gaps.

Drawing upon multiple theories, previous research findings, and real-world case studies, it can be concluded that strategies to enhance citizen participation in environmental education must be designed comprehensively, combining innovative learning approaches, cross-sector collaboration, and adaptive digital technologies tailored to local contexts. Civic Engagement Theory emphasizes the importance of motivation, resources, and mobilization in fostering participation; Collaborative Governance highlights the roles of dialogue, trust, and commitment in building stakeholder synergy; the Technology Acceptance Model shows that technology adoption depends on perceived usefulness and ease of use; Self-Determination Theory underscores intrinsic motivation through competence, autonomy, and relatedness; Social Learning Theory stresses the role of role models and learning by observation; while the Diffusion of Innovations Theory identifies key factors that influence the adoption of new technologies. The integration of these theories proves highly relevant to the Indonesian context, where empirical studies show that multi-stakeholder collaborations (e.g., the ProKlim program), digital innovations (e.g., the Digital Waste Bank in Bandung), and community-based approaches (e.g., Pentingsari Tourism Village) have successfully enhanced citizen participation in environmental education. These cases provide concrete evidence that integrative approaches—combining social, technological, and cultural dimensions—can foster more active, widespread, and sustainable participation. Thus, this study contributes significantly by offering adaptive and applicable strategies for diverse local contexts, positioning environmental education as an effective instrument to build collective awareness, strengthen citizen capacity, and support ecosystem sustainability in a holistic manner.

Table 1. Key Findings on Citizen Participation in Environmental Education

Theory / Concept	Main Focus	Key Findings	Examples / Case Studies in Indonesia
Civic Engagement Theory (Verba et al., 1995)	Citizen participation shaped by *resources, engagement,* and *mobilization*	Participation increases when citizens have access to clear information, strong motivation, and organized mobilization strategies	Eco-house programs, waste banks, and community learning centers promoting behavioral change
Collaborative	Cross-sector collaboration to	Intensive dialogue, trust-building, and joint	Climate Village Program (ProKlim) – involving

Governance (Ansell & Gash, 2008)	achieve collective goals	commitment are essential for successful collaboration	government, local communities, private sector, and universities
Technology Acceptance Model (Davis, 1989)	Technology adoption depends on *perceived usefulness* and *ease of use*	Digital tools enhance enthusiasm and engagement in environmental education	Prabawa-Sear (2018): students more engaged through videos, app-based quizzes, online forums, and ecosystem simulations
Self-Determination Theory (Ryan & Deci, 2000)	Intrinsic motivation fostered by competence, autonomy, and relatedness	Gamification, digital rewards, and interactive systems strengthen intrinsic motivation and sustained participation	Digital Waste Bank in Bandung (Fahriza & Yuliana, 2024): app with points, rankings, and redeemable rewards
Social Learning Theory (Bandura, 1977)	Behavior learned through observation, imitation, and social interaction	Role models inspire broader citizen participation in conservation activities	Pentingsari Tourism Village (Aini & Wulandari, 2021): local leaders modeling waste management and conservation practices
Diffusion of Innovations Theory (Rogers, 2019)	Innovation adoption influenced by *relative advantage, compatibility, complexity, trialability,* and *observability*	Barriers include weak infrastructure, low digital literacy, and conflicting interests among stakeholders	Teguh et al. (2021): failure of app-based reporting programs in remote Kalimantan due to poor networks and low competence
Community Service Approach	Community-based environmental education linked to empowerment	Digital and collaborative community service creates shared learning and capacity building	Taro Tourism Village, Bali (Kalpikawati et al., 2024): digital marketing training for eco-tourism enhancing digital skills and conservation awareness

CONCLUSION

This study emphasizes that enhancing citizen participation in environmental education cannot be separated from relevant program innovations, synergistic multi-stakeholder collaboration, and inclusive use of digital technologies. Environmental education, which has previously relied heavily on conventional approaches, now demands a transformation toward interactive, adaptive, and community-oriented learning based on local needs. Theories such as Civic Engagement, Collaborative Governance, the Technology Acceptance Model, Self-Determination Theory, Social Learning, and Diffusion of Innovations provide a conceptual foundation that explains how participation can grow when intrinsic motivation, technological support, and cross-sector collaboration are present. Empirical studies in Indonesia—such as the ProKlim program, the Digital Waste Bank in Bandung, and education-based ecotourism in Pentingsari Village—offer concrete evidence that the combination of innovation and collaboration can significantly strengthen community involvement. Thus, this study provides both academic and practical

contributions by enriching references related to community service, particularly those focused on sustainable environmental education.

This research expands the understanding of the role of multi-stakeholder collaboration and digital technology in strengthening environmental education, while also enriching the literature on community participation within the context of community engagement. The integration of several theoretical perspectives provides a more comprehensive analytical framework for understanding the factors that influence citizen involvement. For universities, the findings may serve as a reference for designing community service programs in environmental education that are more innovative, interactive, and collaborative. For government, the study provides a foundation for formulating participatory policies that optimize the use of digital technology to mobilize communities. Meanwhile, for communities and the private sector, the results encourage the creation of sustainable partnership models to address environmental issues through collaborative approaches.

This study, however, has several limitations. First, as a literature-based review, its findings depend on the quality and relevance of the available sources and therefore do not directly reflect empirical field conditions. Second, the time span of the reviewed literature (1977–2025) emphasizes recent perspectives but risks overlooking earlier yet still relevant studies. Third, limited access to certain articles or non-academic reports may have reduced the comprehensiveness of the analysis, particularly concerning field practices that are not always academically documented. Consequently, the generalization of findings should be made with caution, as this study functions more as a conceptual and inspirational reference rather than an empirical testing instrument.

For future research, it is recommended to conduct field studies using mixed methods in order to combine the strengths of quantitative and qualitative data to assess the effectiveness of strategies for enhancing citizen participation. Universities can use these findings as a basis for developing community service modules in environmental education that integrate digital innovation and cross-sector collaboration. Local governments are encouraged to strengthen digital infrastructure in rural areas to reduce participation gaps. Furthermore, digital-based environmental programs should be equipped with incentive mechanisms that foster intrinsic motivation and a sense of ownership among citizens. In this way, innovations in environmental education can truly serve as tools for empowerment and sustainability reinforcement, while also enriching references related to community service in the field of environmental education.

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