© JAN 2024 | IRE Journals | Volume 7 Issue 7 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV7I7-1715196

EcoCycle as A Comprehensive UX Design Approach for Ai-Driven Recycling and Sustainability Platforms in US Communities

EMMANUEL ADEGBE

Abstract- Recycling and sustainability models powered by AI are becoming popular among communities in the United States in response to growing challenges in waste management. Many of these systems have low adoption, limited user engagement, and a lack of trust among the masses, often due to poor user experience design. The proposed research is EcoCycle, a conceptual framework for UX design utilizing artificial intelligence, behavioral psychology, and community-based sustainability to develop useful, inclusive recycling systems. With reference to human-centered design, explainable AI, and environmental behavior theories, the conceptualization of sustainability platforms presented by EcoCycle views them as cyclical systems in which user engagement, artificial intelligence, and environmental feedback sustain one another. The framework focuses on transparency, empowerment, inclusiveness, and ethical AI implementation, and makes UX design a core tool for cultivating trust and long-lasting engagement. The study uses a conceptual use case to explain how EcoCycle can achieve better recycling accuracy, increased user retention, and greater community engagement. The paper introduces a new UX-focused approach to the design of AI-powered sustainability technologies and provides designers, policymakers, and practitioners with practical advice. Through the harmonization of AI potential, human experience, and environmental objectives, EcoCycle is a step in the right direction toward holistically designing sustainable technology.

Keywords: User Experience (UX) Design; Artificial Intelligence; Sustainable Technology; Recycling Systems; Human-Centered Design; Behavioral Change; Community Sustainability; Environmental Engagement.

I. INTRODUCTION

In the United States, the challenge of waste management has grown very complicated due to the increased consumption rates, urban expansion, and environmental issues, which have increased in the recent years (Kaza, Yao, Bhada-Tata, and Van Woerden, 2018). The recycling systems maintained by municipalities often face the problem of contamination, poor sorting mechanism, and lack of community involvement, which damages the larger sustainability agendas (Campbell, Oh, and Noh, 2021). Responding to this, numerous communities are moving to using AI-based recycling and sustainability applications such as smart wastebins, automatic sorting stations, predictive collection technologies and behaviorally-conscious recommendation engines aimed at encouraging responsible disposal behaviors (Nahiduzzaman et al., 2023). These technologies will have increased efficiency, cost-saving, and environmental performance (Esmaeilian, Wang, Lewis, and Duarte, 2020). Irrespective of these technical improvements, the effectiveness of recycling platforms that use AI still largely relies on the way that citizens will engage with the technology. It has been observed that numerous systems have low usage rates, inconsistency, and decreased use in the long term (Piras, Alhassan, M., & Masullo, 2023). Such pitfalls are low usability, inadequate access to digital marginalized groups, lack of transparency in AI-based decisions, and general distrust of robotization (Shin, 2021; Zuboff, 2019). Consequently, there has remained a vast disconnect between the technical capacity and an effective human interaction, which will reduce the practical application of these platforms (Wölker and Powell, 2021).

The main problem is that most of the AI-enabled sustainability projects focus on technical optimization and efficiency measurements, including accuracy of sorting, speed of operations or reduction of cost, but not on human-centered designs (Tomitsch, Borthwick, Bendi, and Ahmadpour, 2022). The concept of user experience is frequently viewed as a marginal, secondary factor in system performance and not as a main, pilot one (Norman, 2013). This very focus has led to the division between the goals of the environment, community involvement, and the usability of digital devices (Knowles, Bates, and Hakansson, 2018). Moreover, the current design solutions seldom consider social, behavioral, and contextual factors that influence the way recycling occurs in different communities of the U.S. (Miafodzyeva and Brandt, 2013). As such, no comprehensive UX framework, which comprehensively addresses the alignment of AI functionality with user requirements, ethical issues, and sustainability impacts is evident (Brynjarsdottir et al., 2012). To address this void, this study is meant to suggest that EcoCycle could be an all-encompassing UX design strategy on recycling and sustainability platforms powered by AI specifically. This research aims to solve the long-term adoption and engagement issues by integrating user experience design, AI decision-making system, behavioral change principles, and community-focused sustainability conceptually. The paper is a contribution to sustainability-oriented technologies with its new conceptual framework of UX, which helps to bridge the gap between the design of AI systems and the community-based presence of the environment, provides practical recommendations to policy makers, platform developers, UX professionals and sustainability practitioners.

Underlying Theory and Conceptualizations.

This study is based on the notion of interdisciplinary views on user experience design, artificial intelligence, behavioral change, and community-based sustainability. User experience design is an extremely important factor in influencing how people interact with sustainability technologies. The human-centered design principles focus on usability, accessibility, and inclusiveness and make sure that the systems address the needs of various abilities, degree of digital literacy, and cultural background (ISO, 2019). In the field of civic and environmental technologies, successful UX design is not only visual but also meaning, easily accessible, relevant to real-life practices (Blevis, 2007). Good UX may decrease cognitive load, increase user confidence and sustain a responsible relationship with the environment (Pettersen and Boks, 2008). Systems based on AI are beginning to find their way into recycling and waste management systems to enhance performance and decision-making. The machine learning models aid in waste classification, contamination identification, and operational optimization, whereas predictive analytics can help with the scheduling of collection and recovering the resources more efficiently (Nahiduzzaman et al., 2023; Esmaeilian et al., 2020). Nonetheless, such systems also present major challenges, specifically concerning the issue of algorithmic obscurity, discrimination, and poor explainability (Shin, 2021). The lack of trust and compliance with AI-driven recommendations is likely to occur when users do not comprehend the way and reasons behind its creation (Rai, 2020). By making AI performance in line with transparent, understandable, and ethically sound user experiences, long-term engagement is therefore a necessity (Abdul, Vermeulen, Wang, Lim, and Kankanhalli, 2018).

The effective sustainability platforms are also designed based on behavioral change theories. Nudge theory brings attention to the importance of the design clues used to persuade the users in the favor of desirable actions without forcing them (Thaler and Sunstein, 2008). The Theory of Planned Behavior focuses on the role of attitudes, perceived behavioral control, and social norms in recycling (Miafodzyeva and Brandt, 2013). The Self-Determination Theory places considerable emphasis on the role of autonomy, competence and relatedness in promoting intrinsic motivation (Ryan and Deci, 2000). Taken together, these views have shown that recycling behavior remains stronger as long as digital interaction goes hand in hand with basic human incentives and social situations (Owens and Driffill, 2008). Lastly, community-based digital sustainability is an essential perspective that can be used to comprehend technologies of the public interest. Design participation, equity, and local relevance are the three key concepts in making AI-based sustainability platforms socially legitimate and effective (DiSalvo, 2022). Digital divides, respect toward local norms, and transparency and accountability are vital issues to address within the context of the U.S. (Sengers, Boehner, David, and Kaye, 2005). Collectively, these theoretical bases contribute to the creation of EcoCycle as an all-encompassing, anthropocentric UX paradigm of AI-mediated recycling systems.

The EcoCycle UX Design Approach: Conceptual Overview

EcoCycle is envisioned to be a human-centered user experience design model that is cyclical and incorporates artificial intelligence features, user interaction patterns, and sustainability through the lens of recycling services in the community. Instead of considering UX as a secondary interface issue, EcoCycle introduces it as a key process by which AI-based sustainability technologies deliver legitimacy, adoption, and long-term behavioral influence (Forlano and Mathew, 2014). The model acknowledges that successful recycling systems do not arise just out of algorithmic efficiency but the perennial communication between users and smart systems, and feedback on the environment (Brynjarsdottir et al., 2012).

The philosophy of design that is based on EcoCycle is based on four principles that relate to each other. To begin with, circularity focuses on feedback circuits where user behavior influences the decision-making of AI and system outputs affect user behavior and the environment. This cyclic outline indicates the principles of a circular economy (Geissdoerfer, Savaget, Bocken, and Hultink, 2017) and the iterative approaches to UX design (Norman, 2013). Second, transparency emphasizes comprehensible AI interactions, which means that users can know how recommendations, classifications, or incentives are arrived at (Rai, 2020). EcoCycle aims at establishing trust and confidence in automated sustainability systems by increasing the degree of algorithmic transparency (Abdul et al., 2018). Third, empowerment involves the users as the active contributors to change in the environment as opposed to the passive receivers of the technological instructions (Shin, 2021). By engaging the users in meaningful interaction, providing them with some personalized feedbacks, and displaying visible impact metrics, the users are motivated to feel like they have the agency and ownership of the sustainability outcomes (Owens and Driffill, 2008). Lastly, equity will maintain that EcoCycle-powered platforms are accessible and open to a wide range of communities in the U.S. that conditions differ on digital literacy, socioeconomic background, language, and access requirements (DiSalvo, 2022; Sengers et al., 2005).

In a sense, EcoCycle will be flexible, on a variety of AI-powered sustainability touchpoints. It is used in the application of municipal recycling, smart bin interfaces, community sustainability dashboard, and incentive or feedback system-driven by AI (Esmaeilian et al., 2020; Nahiduzzaman et al., 2023). Providing a single UX experience on all these platforms, EcoCycle facilitates the sense of coherence in user experience, though it enables flexibility in context (Tomitsch et al., 2022). Consequently, the framework can be used to provide a conceptual base of the design of AI-driven recycling systems which are technically effective, yet, at the same time, socially embedded, and human-centered (Forlano and Mathew, 2014).

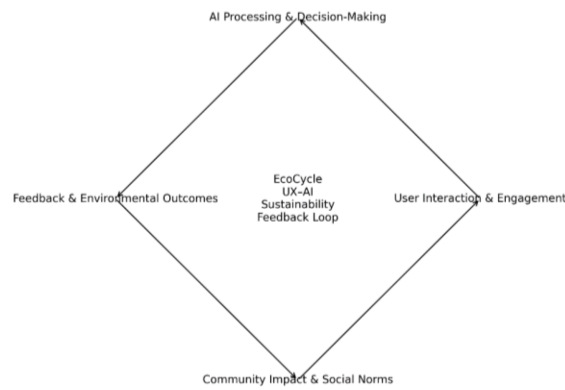

Figure 1: The EcoCycle UX-AI Sustainability Feedback Model

Core Components of the EcoCycle Framework

The EcoCycle model is designed in a way that revolves around interconnected elements that will all contribute to meaningful user interaction, ethical AI application, and sustainable environmental performance. In its simplest form, the structure highly values user participations in form of user-friendly onboarding and interaction patterns that require minimum cognitive input and promote early usage (Pettersen and Boks, 2008). Localization of content and interface is used to prioritize, community-specific recycling rules, norms, and priorities to make it more relevant and understandable (Miafodzyeva and Brandt, 2013). The approaches to motivation, such as gamified features, are tailored to endorse positive behavior without imposing and exhausting behavior (Tiefenbeck et al., 2019). In addition to this interaction

© JAN 2024 | IRE Journals | Volume 7 Issue 7 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV7I7-1715196

layer, there is the AI intelligence element that provides adaptive and context mindful system capabilities. The AI-based suggestions concerning the waste sorting or recycling technique are conveyed in a clear and friendly way, which enables people to comprehend the logic behind the system results (Rai, 2020). The framework promotes adaptive learning, which allows AI systems to optimize recommendations in accordance with observed user behavior without violating any ethical standards associated with minimizing bias, protecting user privacy, and accountability (Shin, 2021). Ethical concerns of AI are thus integrated in the UX design instead of considering them as external governance issues (Abdul et al., 2018).

One of the characteristics of EcoCycle is a feedback and learning loop that links the actions of the user to the perceivable environmental result. Users receive feedback on the appropriateness and effectiveness of their recycling behaviors (Owens and Driffill, 2008) through the use of real-time or near-real-time feedback and about more general benefits (carbon savings or diverted landfill) via visualizations (Brynjarsdottir et al., 2012). Such mechanisms of feedback make learning more solid, motivation is maintained, and even the system itself is developed through a constant improvement (Geissdoerfer et al., 2017). There is a community and social aspect to the framework too, as the recycling behavior is a socially situated behavior (Miafodzyeva and Brandt, 2013). Peer comparison, collective achievement, community challenges, among other features can encourage shared responsibility and the formation of social norms (Nash, Whitmarsh, Capstick, Thoeges, Gouveia, de Carvalho Rodrigues Araaujo, and Westlake, 2021). Further improvement of civic legitimacy and coordination is achieved by integration with local governments and non-governmental organizations (DiSalvo, 2022). Finally, EcoCycle correlates these elements with a sustainability outcome layer that monitors environmental performance, maintains long-term behavioral retention, and scales and relates to policies in different community contexts (Campbell et al., 2021).

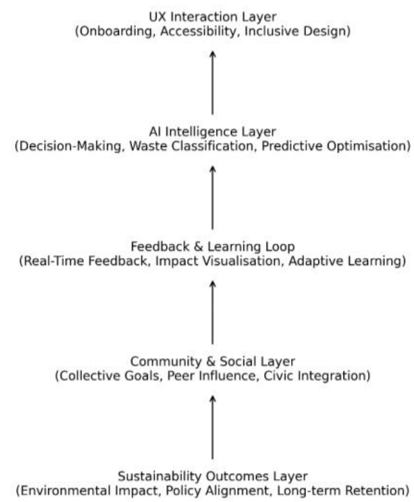

Fig 2: Structural Layers of the EcoCycle Framework

UX Design Principles Underpinning EcoCycle

EcoCycle framework is supported by a series of principles of UX design which makes the human experience one of the main factors of the effectiveness of AI-based sustainability platforms. First of them is a dedication to inclusive and human-centered design. EcoCycle focuses on accessibility as it complies with national standards, including the Web Content Accessibility Guidelines (W3C, 2018) and represents the interface that can be used by individuals with different physical, cognitive, and sensory disabilities. The decisions made at the design stage fully consider the variations in digital literacy without using overly technical language or sophisticated patterns of interaction that tend to disorient the user (Sengers et al., 2005). Multilingual and culturally responsive interfaces also guarantee that recycling information and feedback appeals to different demographic and socio-cultural backgrounds present in the U.S. communities (DiSalvo, 2022).

The second principle is based on trust, transparency, and explainability. EcoCycle is aware that AI-based sustainability platforms exist in the realm of civic spaces that demand the participation of people (Shin, 2021). The framework thus focuses on bold presentation of AI judgments, including waste-sorting suggestions or behavioral guidelines, in straightforward terms and graphics (Rai, 2020).

Honesty in relation to data gathering, storage, and application is a UX issue and not a regulatory requirement (Zuboff, 2019). Incorporating the concept of explainability into the daily interaction, EcoCycle enables building the long-term trust in civic AI systems (Abdul et al., 2018). Lastly, EcoCycle encourages user non-fatigued behavioral reinforcement. Instead of over-notifying or pushing users, the framework uses positive reinforcement as a means of recognizing user effort and progress (Tiefenbeck et al., 2019).

Feedback is designed to be timely, meaningful, and proportionate, helping users sustain motivation over time without experiencing cognitive overload (Pettersen & Boks, 2008). Together, these principles ensure that EcoCycle-driven platforms remain engaging, ethical, and effective in supporting sustained recycling behavior (Norman, 2013).

Implications for Design, Policy, and Practice

The EcoCycle framework offers significant insights into design, policy, and professional practice in AI-based sustainability projects. EcoCycle suggests that designers of user experiences and products move beyond the visual appeal of the interface to experience design, which will help promote behavioral change and environmental consciousness. The feedback on sustainability should not be a side feature of the UX but should be built into the core of the processes, making users aware of the consequences of their behavior. EcoCycle can be an effective strategic planning tool for municipalities and policymakers on digital sustainability. The framework promotes greater adoption and more equal access to diverse communities by foregrounding user experience, transparency, and inclusivity. It will help policymakers view UX design as a governance tool rather than a technical issue. Concerning AI ethics and governance, EcoCycle makes UX a viable tool of ethical AI implementation. Open interfaces, interpretable suggestions, and participation capabilities enable community control, foster accountability, and increase trust in civic AI systems.

RECOMMENDATIONS FOR THE STUDY

According to the EcoCycle model, several practical proposals can facilitate the design and implementation of AI-driven recycling platforms. To start with, technologies focused on sustainability must prioritize human-centered UX design in the initial development phases and ensure they are easy to access, inclusive, and understandable to various users. Second, AI-driven features must be supported by documentation and transparent data practices so users can understand and be confident in the systems' conclusions. Third, municipalities ought to incorporate community participation processes, including collective goals and local partnerships, to strengthen a sense of shared responsibility and social norms. Also, sustainability feedback needs to be structured to enhance positive behavior without overwhelming users, so that it is motivating rather than cognitive. Last but not least, it is necessary to involve designers, policymakers, technologists, and community stakeholders to ensure that AI-based sustainability platforms are socially acceptable, ethically grounded, and aligned with long-term environmental goals.

CONCLUSION

The paper has suggested using EcoCycle as a comprehensive UX strategy for AI-powered recycling and sustainability applications in American neighbourhoods. By incorporating user experience design, AI intelligence, behavioral change principles, and community-based sustainability, EcoCycle addresses the adoption, trust, and long-term participation issues that have persisted over time. The framework has shown that it is important to match AI capability with human experience to transform technological innovation into valuable environmental impacts. EcoCycle emphasizes the value of transparency, inclusivity, and empowerment in civic AI systems, presenting UX design as a tactical tool-based strategic intervention towards sustainable and ethical practices. Finally, the framework recommends interdisciplinary cooperation in UX design, artificial intelligence, public policy, and environmental practice to create sustainable technologies that are not only technically robust but also socially responsible.

REFERENCES

[1] Abdul, A., Vermeulen, J., Wang, D., Lim, B. Y., & Kankanhalli, M. (2018). Trends and trajectories for explainable, accountable and intelligible systems: An HCI research agenda. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (pp. 1-18). ACM.

[2] Blevis, E. (2007). Sustainable interaction design: Invention & disposal, renewal & reuse. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 503-512). ACM.

[3] Brynjarsdottir, H., Håkansson, M., Pierce, J., Baumer, E., DiSalvo, C., & Sengers, P. (2012). Sustainably unpersuaded: How persuasion narrows our vision of sustainability. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 947-956). ACM.

[4] Campbell, H. E., Oh, S., & Noh, Y. (2021). Determinants of recycling behavioral intention among urban residents: An application of the theory of planned behavior. Sustainability, 13(11), 6056.

[5] DiSalvo, C. (2022). Design as democratic inquiry: Putting experimental civics into practice. MIT Press.

[6] Esmaeilian, B., Wang, B., Lewis, K., & Duarte, F. (2020). The future of waste management in smart and sustainable cities: A review and concept paper. Waste Management, 103, 417-431.

[7] Forlano, L., & Mathew, A. (2014). From design fiction to design friction: Speculative and participatory design of values-embedded urban technology. Journal of Urban Technology, 21(4), 7-24.

[8] Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The circular economy–A new sustainability paradigm? Journal of Cleaner Production, 143, 757-768.

[9] International Organization for Standardization (ISO). (2019). ISO 9241-210:2019 Ergonomics of human-system interaction—Part 210: Human-centered design for interactive systems. ISO.

[10] Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a waste 2.0: A global snapshot of solid waste management to 2050. World Bank Publications.

[11] Knowles, B., Bates, O., & Hakansson, M. (2018). This changes sustainable HCI. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (pp. 1-12). ACM.

[12] Miafodzyeva, S., & Brandt, N. (2013). Recycling behavior among householders: Synthesizing determinants via a meta-analysis. Waste and Biomass Valorization, 4(2), 221-235.

[13] Nahiduzzaman, M., Hassan, M. S., Islam, M. R., Hossain, M. I., Khandakar, A., & Azad, A. (2023). Artificial intelligence in sustainable solid waste management: A review and a case study of smart bins. Sustainability, 15(3), 1952.

[14] Nash, N., Whitmarsh, L., Capstick, S., Thøgersen, J., Gouveia, V., de Carvalho Rodrigues Araújo, R., & Westlake, S. (2021). How personal norms encourage sustainable lifestyles: The role of social norms and group identity. Global Environmental Change, 71, 102448.

[15] Norman, D. A. (2013). The design of everyday things: Revised and expanded edition. Basic books.

[16] Owens, S., & Driffill, L. (2008). How to change attitudes and behaviors in the context of energy. Energy Policy, 36(12), 4412-4418.

[17] Pettersen, I. N., & Boks, C. (2008). The ethics in balancing control and freedom when engineering solutions for sustainable behavior. International Journal of Sustainable Engineering, 1(4), 287-297.

[18] Piras, G., Alhassan, I. M., & Masullo, M. (2023). Do smart waste management systems contribute to sustainable development? A critical review and research agenda. Journal of Cleaner Production, 414, 137635.

[19] Rai, A. (2020). Explainable AI: From black box to glass box. Journal of the Academy of Marketing Science, 48(1), 137-141.

[20] Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55(1), 68.

[21] Sengers, P., Boehner, K., David, S., & Kaye, J. J. (2005). Reflective design. In Proceedings of the 4th decennial conference on Critical computing: Between sense and sensibility (pp. 49-58). ACM.

© JAN 2024 | IRE Journals | Volume 7 Issue 7 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV7I7-1715196

[22] Shin, D. (2021). The effects of explainability and causability on perception, trust, and acceptance: Implications for explainable AI. International Journal of Human-Computer Studies, 146, 102551.
[23] Thaler, R. H., & Sunstein, C. R. (2008). Nudge: Improving decisions about health, wealth, and happiness. Yale University Press.
[24] Tiefenbeck, V., Goette, L., Degen, K., Tasic, V., Fleisch, E., Lalive, R., & Staake, T. (2019). Overcoming salience bias: How real-time feedback fosters resource conservation. Management Science, 65(1), 396-413.
[25] Tomitsch, M., Borthwick, M., Bendi, M., & Ahmadpour, N. (2022). Designing for the circular economy. Routledge.
[26] Wölker, A., & Powell, T. E. (2021). Algorithms in the newsroom? News readers' perceived credibility and selection of automated journalism. Journalism, 22(1), 86-103.
[27] World Wide Web Consortium (W3C). (2018). Web Content Accessibility Guidelines (WCAG) 2.1. https://www.w3.org/TR/WCAG21/
[28] Zuboff, S. (2019). The age of surveillance capitalism: The fight for a human future at the new frontier of power. PublicAffairs.