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Transforming Waste Awareness through Aakri: An AI-Based Self-Directed Learning Approach for Sustainability

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Abstract

Sustainable development requires effective waste management systems that serve as essential foundations for urban areas experiencing rapid population growth due to rising consumption levels. People struggle to learn proper waste disposal methods because several waste management policies and community-based waste classification training programs have failed to achieve their educational objectives. This study introduces Aakri, which operates with ReSustainability as its homegrown AI waste management training platform, enabling students to learn waste management practices through their own learning processes. Through its human-AI system, Aakri provides interactive learning modules that deliver short educational content that can be expanded to support more users. The platform uses advanced large language models to deliver customized user feedback that helps users learn about waste segregation and decision-making techniques. Aakri produces educational materials that meet users' needs to facilitate their learning processes. The platform provides users with continuous learning opportunities through its waste scanning system, virtual sustainability metrics, and individualized learning interfaces.A user-centered approach was used to measure the performance, user experience, and capacity of the platform to create user engagement. The study results demonstrate that Aakri improves users' knowledge about sustainable waste management methods while providing them with a user-friendly interactive experience. The research findings show how human expertise combined with AI systems creates educational solutions that can be made available to all users and expanded to reach more people.This study investigates the operation of AI-powered educational technologies and demonstrates that self-directed technology-based learning methods help India achieve its sustainability objectives through better waste management practices.

Keywords: AI-based educational technology, Sustainable waste management, Self-directed learning, Waste segregation, Interactive learning systems, Human–AI collaboration, Sustainability awareness, Environmental education, Digital learning platforms

1. INTRODUCTION:

Proper waste management serves as an essential foundation for sustainable development; however, it creates significant difficulties for people and communities across India, which is experiencing diverse and fast-growing urbanization. People today face greater challenges because their consumption patterns and waste streams have become more complex, requiring them to properly separate and dispose of their waste. Individuals have trouble maintaining their waste management practices because governments and municipalities, along with sustainability organizations, have established multiple programs to enhance waste management methods (Kaza et al., 2018; Abdel-Shafy & Mansour, 2018). The variation in waste types, including recyclable materials, biodegradable items, landfill waste, and hazardous substances, creates challenges, as different waste management rules, systems, and understandings of waste management differ in various areas. Improper disposal occurs because people become confused, making sustainability efforts less effective (Kumar et al., 2017; Zhang et al., 2015).

The development of current technological solutions has led to the establishment of sensor-enabled smart bins, along with image-based waste classification systems that use deep learning technology and digital awareness campaigns as solutions to these problems (Chen et al., 2020). While these solutions boost efficiency across organizational systems, they fail to provide users with ongoing, customized, and convenient learning resources that enable them to comprehend and implement sustainable waste management practices in their daily activities (Okedu et al., 2022). Modern educational technologies have opened new possibilities that allow educational institutions to apply sustainability education in more customizable and engaging ways that meet learner requirements (Zou et al., 2025). Presently, educational institutions must adopt digital learning platforms that enable students to grasp challenging sustainability topics through active learning methods and independent study (UNESCO, 2021). Through their interactive learning materials, the platforms create an essential connection that helps users understand information before they can implement practical solutions, providing accessible, real-world contextual knowledge.

This study presents Aakri (powered by ReSustainability) as an artificial intelligence (AI) educational technology platform that enables users to learn about waste management through its self-paced study program. Aakri delivers short, interactive content that allows users to learn through structured educational materials and user-controlled learning activities (Dede, 2014). The platform uses a human-AI partnership model to provide personalized user feedback while helping users learn waste segregation techniques and create educational materials that match their specific requirements (Luckin et al., 2016). Aakri employs waste scanning technology, sustainability indicators, and personalized learning dashboards to create an interactive experience that leads to sustainable behavior changes.

The primary aim of this research is to investigate how artificial intelligence-based educational tools improve sustainability education while promoting effective waste disposal methods. This study investigates the following research questions:

- RQ1: To what extent does Aakri improve users' understanding and knowledge of sustainability and waste management?
- RQ2: How do interactive learning materials, which are divided into small sections, and the overall system usability affect user learning outcomes?
- RQ3: How do Aakri platform users utilize different methods to track their progress and interact with its features?

A user-centered evaluation method was employed to assess learning outcomes, system usability, and user engagement activities. Participants were required to use the platform for a fixed period while their activities were recorded using assessment tools and behavioral data.

This study develops effective educational programs for sustainability through a combination of AI, educational technology, and user-centered design methods. Aakri helps individuals make better waste management choices that support environmental protection efforts and contribute to building a sustainable society.

2. LITERATURE REVIEW

2.1 Technologies for Promoting Sustainability: Technological advancements have significantly transformed waste management processes and sustainable practices across multiple operational environments. In the past few years, researchers have used artificial intelligence and deep learning methods to develop systems that automatically detect and classify various waste materials (Chen et al., 2020). These methods have successfully demonstrated their ability to classify various types of waste, including medical waste, plastics, and mixed urban waste streams. The new waste sorting methods achieve better results because they enable more precise waste sorting, which helps organizations achieve their environmental goals (Alam, 2023).Interactive technologies that engage users through fun elements must be used to successfully build sustainable behavior patterns in people. Gamification enables users to participate in learning activities using reward systems, competitive tasks, and performance assessments to create an interactive learning environment. Applications that promote eco-friendly behaviors, such as sustainable driving and responsible consumption, have shown positive behavioral outcomes. Waste management educational games use real-world waste scenarios to help players learn how their choices impact the environment through interactive gameplay (Bibri, 2021; Hariyani et al., 2025).In addition, machine learning enabled applications have been integrated into gamified platforms to more accurately assist users in sorting waste (Fogg, 2003). The systems provide entertainment through their games, which help users learn sustainable practices. Users can now see how their waste affects the environment through Augmented Reality (AR) while receiving real-time instructions about safe waste disposal (Dede, 2014). The technologies create links between environmental concepts that people find difficult to understand and actual environmental experiences that users can encounter.

Sustainability-focused technologies now include personalization as an essential component. The system creates customized recommendations for users who display specific behavior patterns and personal preferences, reducing food waste and promoting recycling activities (Zhang et al., 2015). Recommendation systems help users by providing recycling instructions at consumption points while showing them ways to reuse excess food. The personalized methods help people make better environmentally friendly choices throughout their daily activities assist users.

2.2 Adaptive Systems and Language Models in Educational Technologies: The development of educational technology has transformed through adaptive learning systems that create personalized learning experiences, which change over time. The systems modify their teaching materials and assessment methods to match each student's distinct learning patterns and choices. Research demonstrates that adaptive feedback (AF) systems lead to better educational outcomes than standard methods that use uniform approaches (Luckin et al., 2016). The implementation of adaptive learning environments has proven to enhance student achievement across mathematics and science disciplines while sustaining student interest and motivation.The integration of AI into adaptive systems has increased their functionality through new developments. AI-powered learning environments in mixed reality provide STEM education through interactive and context-aware learning experiences. The use of peer feedback systems as a collaborative method has proven to enhance the standard of student-generated content, demonstrating the importance of social learning and shared knowledge in educational environments.

The introduction of large language models (LLMs) in the last few years represents a major advancement that enables content creation and learner assistance through LLM technology. LLMs produce educational content that includes explanations, problem sets, and comprehension questions. Research indicates that students find learning easier when they use tools powered by LLM technology. In certain instances, AI-produced educational materials have matched or surpassed the quality of content created by human authors.

LLMs have gained popularity as educational tools because they assist teachers with lecture development, curriculum creation, and content evaluation. The systems generate assessment results that match learning exercises, making them suitable for use in interactive educational settings. LLMs function as digital tutors by helping students study difficult subjects while offering them customized educational support.

This study combines adaptive learning methods with LLM-based feedback systems (Meyer et al., 2024) to create the Aakri system, which uses ReSustainability technology. The platform employs artificial intelligence (AI) as a virtual learning partner to deliver customized learning experiences and interactive assistance, helping users understand sustainable waste management challenges (Kopecká et al., 2024). Combining adaptive systems with advanced language models shows the potential to develop sustainable educational solutions through interactive and scalable learning methods.

3. METHODOLOGY

3.1 Aakri Application: Aakri is an educational platform that uses AI to deliver web-based learning materials and self-paced study to teach users about sustainable practices and waste management. The platform employs interactive educational materials to provide customized learning experiences that enable users to engage with the system through community-based learning (CBL) methods.

3.1.1 Architecture: Aakri utilizes a cross-platform development framework, including Flutter, to create a web application accessible from multiple devices. The system employs a cloud-based NoSQL database solution, including Firebase, to provide users with real-time data access and system expansion capabilities.

The platform uses advanced large language models (LLMs), which it connects through API integration to power its main operational intelligence. The models generate educational materials delivered to users along with customized assessments and recommendations for learning pathways. The system design combines human intelligence with artificial intelligence (AI) technology to enhance the user experience through AI-powered features that use supervised data and standardized procedural rules to ensure precise results.

3.1.2 Learning Content: The Aakri platform delivers learning through a dynamic and continuously updated content feed. The platform's content feed combines various educational materials, including: Static Informational Posts: These posts provide concise, bite-sized knowledge on sustainable waste management, covering topics such as waste segregation, environmental impact, recycling practices, and pollution control. The site's content includes AI-driven material and user-generated content, resulting in an extensive collection that meets current needs. AI-generated content is synthesized from credible sustainability sources and optimized for clarity and engagement. The platform uses interactive quizzes to test waste-sorting abilities through a gaming system that requires users to categorize waste materials into recyclable, biodegradable, and hazardous waste categories. The quizzes can be created by users or generated by artificial intelligence (AI), encouraging users to become more involved in the testing process. The system provides users with immediate feedback that explains their mistakes and helps them develop their skills through practice. The system uses LLM technology to create contextual waste management learning paths based on users' specific answers to questions. The system verifies its quiz assessment process using established environmental standards and authentic database resources to achieve accurate results while reducing misinformation.

3.1.3 Features for Enhancing Awareness of Sustainability: Aakri integrates multiple groundbreaking functionalities to promote user participation while establishing permanent changes in user behavior throughout their time on the platform.

Progress Tracker: The platform tracks user development over different periods by showing waste classification accuracy and areas needing improvement. This feature enables users to learn from their experiences while motivating them to further enhance their skills.

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Sustainability Indicators: Users earn virtual environmental credits through quiz and activity performance. The credits allow users to visualize their environmental impact through sustainability metrics that indicate carbon reduction equivalents (CREs).
Leaderboard System: The system employs leaderboards to foster competition among users, who are ranked according to their sustainability scores, motivating them to actively participate and remain engaged.
Search and Waste Identification Tools: Aakri allows users to find waste materials using its search tool and AI-based waste scanner, which provides information about correct disposal methods. The scanner employs image recognition models trained on various waste datasets to deliver precise waste classification.
User-Generated Content: The platform enables users to create content through posts and quizzes, fostering a learning community that develops educational material for the platform.

3.2 User Study

The user study examined the effectiveness and usability of Aakri through the participation of 36 college students who studied digital learning and web usability. The study required participants to use the Aakri platform for eight weeks while testing all available platform features, including interactive content and quizzes as well as sustainability tools. The application required participants to complete one static informational post and one interactive waste-sorting quiz as the minimum requirements for meaningful participation.

Figure 1: Educational Content in Aakri Web Application

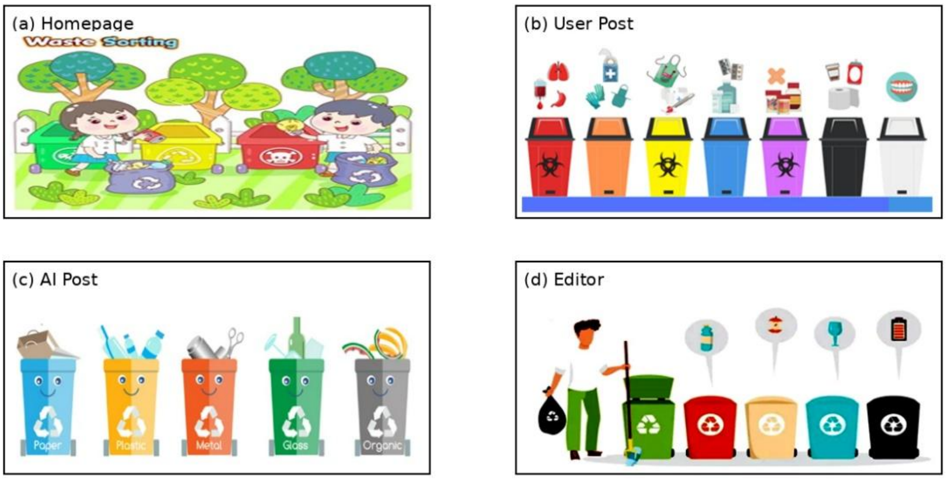

Figure 1: Educational Content in the Aakri Web Application (a) Homepage displaying an expert-created post within the content feed (b) Example of a user-generated post (c) AI-generated (synthesized) educational post (d) Editor interface for creating static posts

The study used pre-study and post-study surveys to measure how Aakri affected participants' understanding of sustainability. The surveys asked about the essential elements of sustainable waste management, including waste segregation, recycling practices, composting, the Zero Waste hierarchy, and the environmental impact of daily waste generation. The researchers used a 5-point Likert scale to measure responses, with 1 indicating strong disagreement and 5 indicating strong agreement.

Figure 2: Interactive Waste-Sorting Quizzes in Aakri

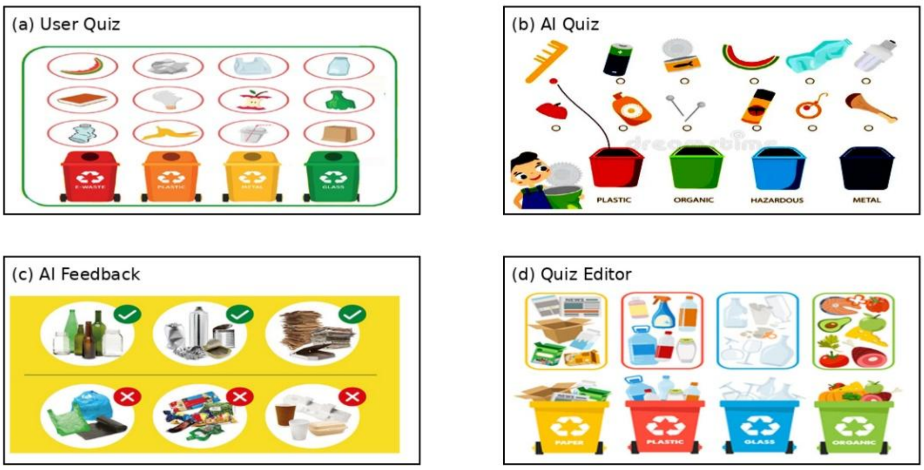

Figure 2: Interactive Waste-Sorting Quizzes in Aakri (a) User-created quiz interface (b) AI-generated quiz (c) AI-assisted feedback when a user makes an incorrect classification (d) Quiz creation editor

The study assessed the perceived knowledge of participants while testing their practical ability through a waste classification task that appeared in both surveys. The students were required to sort 15 common household items into their correct waste disposal categories. The task enabled researchers to evaluate the progress of students in applying their knowledge about waste sorting to actual decision-making situations (Figure 1 & 2).

The System Usability Scale (SUS) was used as the primary assessment tool in the post-study survey to measure both usability and total user experience. The participants used a 5-point Likert scale to evaluate usability-related statements, which helped researchers gather organized feedback about the user-friendliness, interface design, and user interaction strengths of the platform. The researchers expected participants to share their thoughts about the study along with their recommendations for better study outcomes (Figure 3).

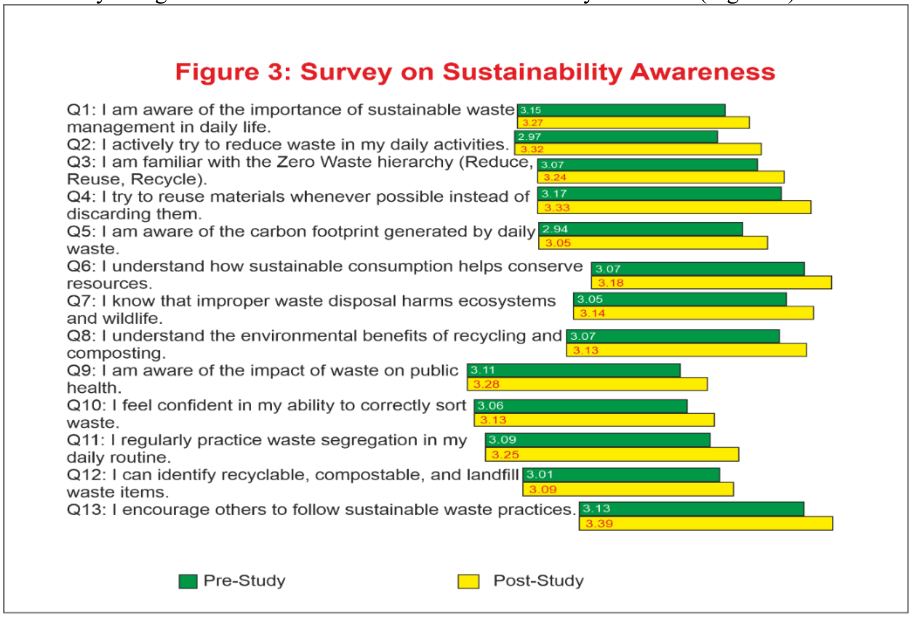

Figure 3: Users' sustainability awareness questions and its scores pre-study and post-study.

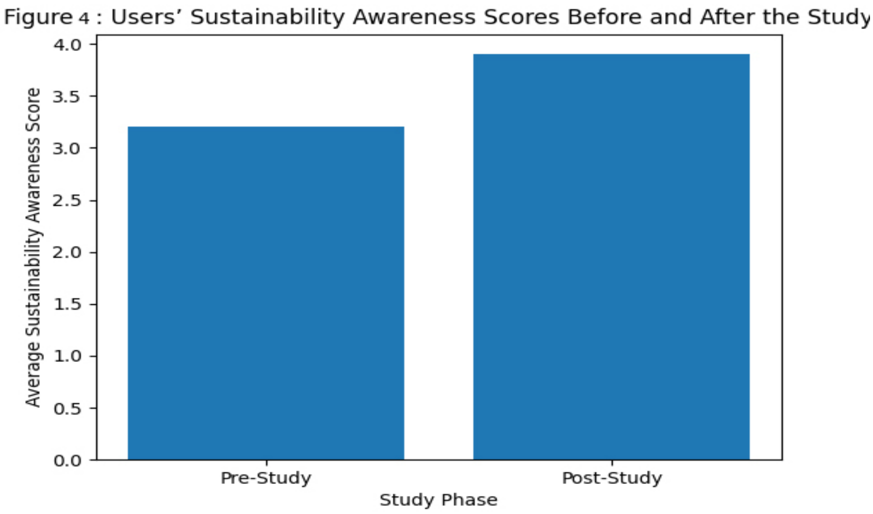

Figure 4: Users' Sustainability Awareness Scores Pre-study and Post-study

The investigation merged survey findings with user interaction information, including content creation, quiz-taking, and platform feature usage patterns. This study aimed to produce comprehensive results about the effectiveness of Aakri in increasing sustainability knowledge, teaching waste management skills, and providing a simple yet enjoyable learning experience through user engagement analysis and pre- and post-study data comparison.

3.3 Aakri Post Content Analysis: The study assessed the effectiveness of educational content through Aakri ReSustainability content, which incorporated two analysis methods that combined novelty scoring with a quality assessment framework. The novelty score measures content originality and diversity, while the quality matrix system evaluates sustainability and learning value. The method evaluates all posts on the platform through two types of content, which include AI-produced material and user-created content.

3.3.1 Novelty Score: The novelty score was designed to measure the degree of uniqueness in the content shared on the Aakri platform. The system achieved this goal through the application of topic modeling methods that operated alongside fundamental concepts of information theory.

The researchers used Latent Dirichlet Allocation (LDA) to discover hidden thematic patterns within the collection of posts. The authors created a topic model that represented each post as a combination of different topics, allowing for the identification of the main themes present in the entire dataset. The researchers applied standard text processing tools to preprocess all posts through tokenization, which created a term-frequency matrix. The study used three main topics from each post as the basis for calculating novelty.

The process of topic extraction resulted in a probability distribution that displayed the topic distribution for each post. The study measured novelty through the calculation of joint probability, which involved multiplying selected topic probabilities. The joint probability measures how frequently or infrequently a particular topic combination occurs in the dataset.

The concept of **self-information (surprisal)** was then applied to compute the novelty score:

$$I(p) = -\log_2\left(\prod_i P(t_i \mid p)\right)$$

where I(p) represents the novelty score of post p, and $P(t_i|p)$ denotes the probability of topic t_i in that post. Higher values of I(p) indicate more novel and less frequent topic combinations, thereby highlighting unique and potentially insightful content. Posts were ranked based on their novelty scores to identify and prioritize innovative contributions within the platform.

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3.3.2 Quality Matrix

The educational and practical value of content is not shown through novelty, which only marks unique content. The development of a quality matrix enables the evaluation of post content, demonstrating how effective it is in supporting sustainable waste management practices.

The quality assessment framework used Local Environmental Stewardship Indicators (LESI) as its foundation and added essential elements from the Zero Waste Hierarchy (Reduce, Reuse, Recycle) system. The two frameworks established six primary indicators that describe their locations as follows:

- Sustainable Use
- Education
- Advocacy
- Waste Reduction
- Reuse
- Recycling

The post content was analyzed through these indicators to assess its potential for raising sustainability awareness and driving changes in environmental practices.

This evaluation process utilized large language models (LLMs) to study the written material that appeared in posts. The models required a structured prompt that explained the assessment method to evaluate each post through established indicators. The content held the following two values for each indicator, which received a binary score:

- 1 if the indicator was present in the content
- 0 if the indicator was absent

The method analyzed both AI-generated content and user-generated content. The study used multiple LLM outputs to verify results, whereas manual evaluation resolved any existing differences. The aggregation of scores resulted in average quality assessments for all content types.

The systematic evaluation method allowed researchers to compare AI-generated posts against human-created content, showcasing the unique aspects of each type. The research demonstrates how various content creation methods advance sustainability education and increase public awareness while encouraging proper waste management practices.

4. EVALUATIONS AND RESULTS

4.1 Impact on Sustainability Awareness: The results from the pre- and post-study assessments indicate that Aakri (powered by ReSustainability) provided users with significant progress in both their environmental knowledge and waste handling skills. Participants demonstrated substantial improvement in their ability to identify essential differences between composting and recycling and to understand the Zero Waste hierarchy system. Users achieved conceptual understanding results while developing higher confidence in their capabilities to handle everyday waste disposal activities. The waste classification task results showed improvement, as the average accuracy increased from 0.79 (pre-study) to 0.83 (post-study) during the study (Figure 4).

The public gained environmental knowledge about waste disposal methods due to this project, but their understanding of carbon footprint effects showed less progress. The platform successfully enhances users' practical skills and conceptual knowledge, but its next version should place greater emphasis on teaching users about environmental damage. Research results indicate that Aakri serves as an effective tool for teaching sustainability concepts and facilitating the transformation of environmental behavior.

4.2 Post Content Analysis: The research examined 79 posts, consisting of 36 user-generated posts and 43 AI-generated posts. User-generated content created different formats, including memes, infographics, and posters, while AI-generated content maintained a single text format that delivered consistent informational content across all its textual elements.

The evaluation process required content assessment through the development of indicators based on environmental stewardship principles and the Zero Waste hierarchy. Table 1 displays these indicators.

Table 1: Indicators used to analyze the content of a post

Indicator	Description
Sustainable Use	Focus on responsible waste practices that minimize environmental impact and promote long-term sustainability
Education	Informing and educating users about proper waste management and environmental consequences
Advocacy	Promoting environmental responsibility, policies, and awareness campaigns
Reduce	Encouraging minimization of waste generation and resource use
Reuse	Promoting repeated or alternative use of materials and products
Recycle	Supporting recycling practices and transformation of waste into reusable materials

The evaluation process used these indicators to assess both user-created content and AI-generated content through a systematic scoring method. The results of this comparative analysis are presented in Table 2.

Table 2: Comparison of user-created and AI-generated posts across different indicators

Indicator	User-Generated (Mean ± SD)	AI-Generated (Mean ± SD)	t-value	p-value	Cohen's d	Interpretation
Sustainable Use	0.23 ± 0.41	0.27 ± 0.43	-0.45	0.65	0.09	Comparable
Education	0.72 ± 0.42	1.00 ± 0.00	-3.68	<0.001	0.94	AI stronger (structured learning)
Advocacy	0.14 ± 0.19	0.21 ± 0.42	-1.02	0.31	0.22	Comparable
Reduce	0.21 ± 0.43	0.19 ± 0.40	0.25	0.80	0.05	Comparable
Reuse	0.13 ± 0.25	0.08 ± 0.25	0.92	0.36	0.20	Comparable
Recycle	0.41 ± 0.47	0.08 ± 0.27	3.78	<0.001	0.87	Users stronger (practical familiarity)
Novelty Score	9.51 ± 2.52	11.63 ± 0.82	-4.96	<0.001	1.15	AI stronger (diverse topics)

Group comparisons between user-generated and AI-generated content were conducted using an **independent samples t-test (two-tailed).**

The analysis included **36 user-generated posts and 43 AI-generated posts**.

A significance level of $p < 0.05$ was used to determine statistical differences between groups.

Effect sizes were calculated using **Cohen's d** to assess the magnitude of differences.

Cohen's d values were interpreted as follows:

- 0.00–0.19: Negligible difference
- 0.20–0.49: Small effect
- 0.50–0.79: Moderate effect
- ≥ 0.80: Large effect

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Indicators with statistically significant differences ($p < 0.05$) highlight areas where either AI-generated or user-generated content demonstrates relatively stronger contributions, while non-significant results indicate comparable performance between the two content types.
The study results show that Aakri's educational programs for sustainability depend on both user-created content and AI-generated materials. The study results indicate that two content types coexist because they both contain valuable information, but one type does not provide a competitive advantage over the other. AI-generated content demonstrates better performance in educational and novelty metrics because it provides organized, reliable, and diverse information about sustainability topics. The AI system effectively helps users build their conceptual knowledge base while introducing them to multiple environmental concepts.
Users create content that focuses more on recycling because they have better knowledge about this element of the zero waste hierarchy. People understand recycling better than they understand reduction and reuse in accordance with actual environmental practices.
The content types show only small differences, which approach the point of being statistically non-detectable for sustainable use and advocacy, as well as reduce and reuse. Both users and AI systems make essential contributions to sustainability learning requirements.
The effect size analysis further supports this interpretation. The education, recycling, and novelty areas show substantial effects, creating distinct differences between the three areas; yet, they do not establish one area as more important than another. The AI system provides organized content while presenting various themes to users who offer real-world experience, dynamic thinking, and hands-on skills. The research results demonstrate that combining human-created content with AI-generated material establishes an effective educational system that improves environmental sustainability knowledge and promotes proper waste disposal methods.
4.3 Aakri Usage and Behavioral Analysis: The user study recorded that participants interacted with Aakri (powered by ReSustainability) for an average duration of 11 minutes and 3.3 seconds. The time users spent across different features shows that most of their time was dedicated to the content feed, as users spent their time reading and interacting with educational materials (Figure 5).

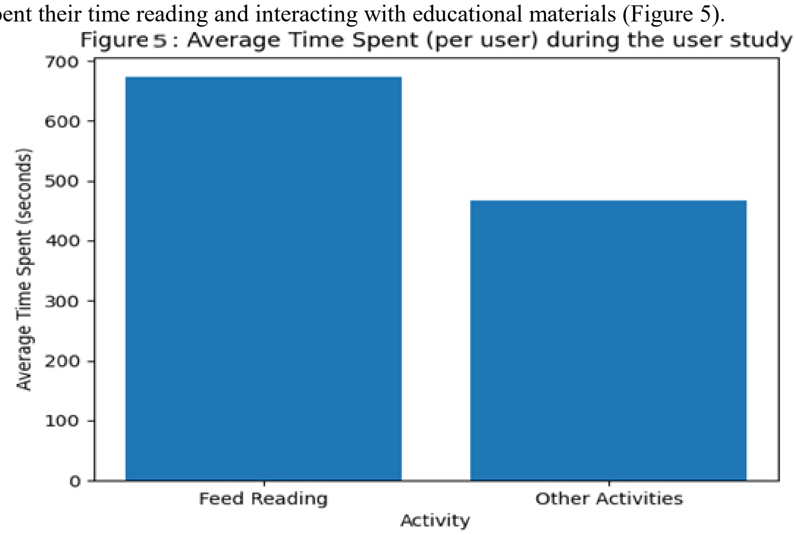

Figure 5: Average time spent (per user) during the user study.

Researchers studied 421 user actions, which they tracked sequentially to identify how users behaved on the platform. They divided the actions into six distinct categories, which included:

- R: Reading the feed
- S: Social interactions (likes, comments)
- Q: Taking quizzes
- L: Searching or using the waste scanner
- P: Publishing posts
- PQ: Publishing quizzes

Researchers used a Hidden Markov Model (HMM) to create their user behavior model. A three-state model proved to be the optimal solution according to evaluation criteria because it displayed different user engagement patterns.
The first state (HS_2) represents entry-level engagement, where users primarily focus on consuming content. Users in this state read the feed most often, while they create quizzes and engage in social and search activities only infrequently. First-time users of Aakri start working with the system to explore and access content. The second state (HS_3) reflects a diversified engagement phase, where users actively explore multiple features of the platform. Users in this state demonstrate active engagement through their participation in reading quizzes and content creation activities, as well as their use of search functions and social interactions. The user experience has shifted from users who consume everything passively to users who now actively participate on the platform. The third state (HS_1) establishes a concentrated educational period that requires students to focus on their testing activities. Users who enter this state dedicate themselves to testing their knowledge through active study while ignoring all other activities. Users who enter this state will maintain their current status because they continue to focus on learning.
The users follow a cyclical engagement process that starts with content consumption and progresses to wider interaction before they choose to engage in learning through quizzes. Aakri proves effective in transforming users from basic awareness into active learning and skill acquisition according to this process.
4.4 Usability of Aakri : The System Usability Scale (SUS) assessment of Aakri, which operates through ReSustainability, produced a total score of 73.6, demonstrating both good and acceptable usability. The platform proved to be user-friendly through its multiple integrated systems, which allowed users to master its functions while navigating through the platform. The usability results show how different content types affect user experience when viewed in conjunction with Table 2 results. The system achieves improved usability and user engagement through its combination of AI-generated content and content created by users.
AI-generated content, which demonstrates stronger performance in education and novelty, contributes to usability by providing structured, consistent, and easy-to-understand information. Users found that the concise and organized nature of AI-generated posts made complex sustainability concepts more digestible, thereby supporting efficient learning. The usability metrics demonstrate that users achieved rapid system understanding along with successful system operation. User-generated content demonstrates greater dedication to recycling, which improves usability through its particular context and user familiarity. The platform becomes more relatable and engaging because users can comprehend

real-world situations through its various content formats, which include posts, quizzes, and interactive elements. Users experience a better learning process because they receive content that matches their current knowledge and established routines.

User feedback confirms the presence of complementary strengths, which Table 2 identifies. The structured AI guidance, together with user-generated creative input, creates both comprehension and interactive elements. Users can participate more actively while they learn through AI-assisted quizzes, interactive feedback, and sustainability visualizations, which help them achieve better learning outcomes.

Aakri's usability depends on two factors: its interface design and its content ecosystem, which uses AI to maintain consistent content standards while users introduce their unique content. This combination creates an educational environment that users find easy to navigate while they learn about sustainability in an interactive and enjoyable way.

5. CONCLUSIONS

5.1 Summary: Aakri (powered by ReSustainability), which serves as an AI-based online educational platform, demonstrates its ability to create sustainable learning experiences through its self-paced interactive learning methods. The user study results show that Aakri successfully helps users develop their sustainability knowledge, waste sorting abilities, and understanding of sustainability concepts.

The platform created an active educational space that combined AI-generated content with user-generated content to support learners in acquiring knowledge while participating in learning activities. The users established a collaborative connection with the platform through their creation of posts and quizzes, which they used to access educational materials. The user behavioral analysis discovered different engagement patterns that showed users moved from content consumption to interactive exploration and, in some cases, to structured learning through quiz assessments. The platform helps users strengthen their learning through its three different stages, which illustrate the path to advanced learning. The Aakri system achieved excellent usability results because users found the platform easy to use while executing their tasks through its various features. The system achieves optimal usability through its design, which combines operational functions with user-centered design, enabling all types of users to access the system. The research demonstrates that AI educational technologies, which use large language models together with interactive learning systems, have great potential to support sustainable waste management practices. Aakri develops an environmentally sustainable solution that achieves a significant impact by combining technological innovations with educational methods and user-friendly design.

5.2 Limitations and Future Work: The study encountered certain restrictions despite its successful results. The study involved 36 participants, which creates challenges for applying its results to individuals outside the study group. The study period lasted eight weeks, which does not provide enough time to observe how the platform affects user behavior and their sustainable practices over extended periods.

Future research should focus on expanding the study to include a larger and more diverse participant base across different demographic and geographic contexts. Longitudinal studies will become essential for examining how Aakri affects users through knowledge retention and their behavioral transformations and environmental awareness over time.

The platform needs advanced technological improvements, which should include deeper gamification elements, more refined personalized learning pathways, and stronger social interaction mechanisms. Real-world waste management systems and localized guidelines should be integrated into the system to enhance contextual relevance in diverse settings such as India.

Aakri functions as an innovative sustainability learning tool that requires ongoing development and assessment to achieve maximum effectiveness and growth potential for sustainable waste management solutions.

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