Personalized Sustainability Assistant: AI-infused Context Engineering to Connect Sustainability Understanding to Sustainable Actions

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Abstract

Despite increasing sustainability awareness, an "intention-action gap" prevents individuals from adopting pro-environmental behaviors in their daily lives. Generic and one-size-fits-all information campaigns often fail to account for an individual's specific context, constraints, and motivations. This paper introduces a novel AI-powered system designed to bridge this gap by delivering personalized, context-aware sustainability recommendations. Our system consists of three core AI-based components: (1) a dynamic repository of actionable sustainability tips tailored to specific environments, such as corporate offices, university campuses, etc.; (2) a personalized user profile construction via an adaptive questionnaire with modern chatbot user interface; and (3) personalized recommendations of relevant sustainable actions and simulations for their potential environmental and financial savings. We present a functional prototype under the setting of a university campus and discuss a path toward deployment and evaluation in the real world. This work demonstrates the potential of personalized AI systems to foster a concrete and lasting pro-environmental behavior change.

CCS Concepts

• **Applied computing → Interactive learning environments**.

Keywords

sustainability learning, behavioral analytics, eco-feedback technology, environmental impact, sustainability lifestyle, theory of change, personal informatics.

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1 Introduction

Sustainability is a critical global imperative, yet translating awareness into action remains a challenge. Despite growing consciousness, people struggle to implement sustainable practices due to a lack of visibility regarding their personal impact and a lack of clear, actionable steps. This disconnect is often explained by the *Theory of Planned Behavior* (TPB) [1, 10], where perceived behavioral control—confidence in one's ability to act—is diminished when impact is invisible. Furthermore, *Self-Determination Theory* (SDT) suggests behaviors are better adopted when they satisfy needs for autonomy, competence, and relatedness [6].

While eco-feedback technologies exist, such as carbon calculators [7, 12], they often stop at raising awareness without facilitating behavior change [9, 13]. They rarely offer personalized action frameworks or simulation mechanisms. To address this, we present **MyEcoPal**, a web application that connects intrinsic and extrinsic motivation to build sustainable behaviors. Guided by the *Theory of Change* (ToC) [5], MyEcoPal engages users in calculating footprints, visualizing impact, exploring "what-if" scenarios, and tracking actions.

Research suggests that awareness of carbon footprints can lead to behavior change, but its effectiveness depends on how it is delivered. For instance, providing information alone, such as through a carbon footprint calculator [13], increased knowledge and changed attitudes but did not translate into action [9]. However, personalized information, combined with feedback and social influence, was more effective [4, 11], and can significantly reduce energy consumption by up to 19% [2]. It also shows that the most successful interventions combine multiple types of goals, such as energy and mobility, unlike single-strategy efforts that often yield small or no effects [9]. MyEcoPal implements an integrated approach—combining a Carbon Footprint Calculator, an Impact Simulator, and a Sustainable Action Framework—to enhance users' understanding & motivation and link to actionable steps. We applied the ToC aligned with Sustainability Science [8] by engaging users in calculating their personal carbon footprints, helping them visualize the impact and explore "*what-if*" scenarios through simulations, connecting to actionable steps, and tracking the actions. MyEcoPal is designed to provide the technology and interfaces to support documenting a personal sustainability journey, which was previously easily unnoticed or very challenging to keep track of.

We address three research questions: (1) Which design elements best support bridging the gap? (2) To what extent does the system enhance awareness? (3) What behavioral characteristics are influenced by usage?

2 Methodology

2.1 Sustainable Actions: Repository, Taxonomy, AI-Augmented Impact Evaluation

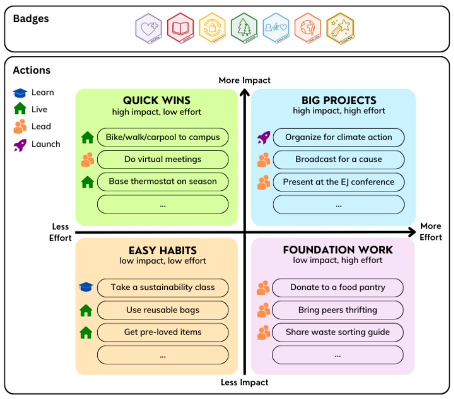

Figure 1: Based on the school's sustainability strategic plan and playbooks, a Sustainability Action Engagement Taxonomy diagram is created to overview of a low-fidelity prototype of MyEcoPal's Action interface. There are 264 expert-curated sustainable actions categorized in a quadrant matrix according to the action's environmental impact and implementation effort. Each action is labeled by its engagement type (Learn, Live, Lead, or Launch) and contributes to the progress in one of the seven sustainability badges.

2.1.1 Data Repository & Sustainability Engagement Taxonomy. A comprehensive repository of sustainable actions forms the foundation of MyEcoPal. The repository consists of 264 unique sustainable actions manually curated by the Center for Sustainability from the author's university. These actions are organized into seven primary badges: *Scholastic, Climate Action, Mindful Consumption, Environment, Common Good, Well-Being, and Change Maker.* Within each badge, actions were further classified by engagement type (Learn, Live, Lead, Launch), representing different modalities of sustainable engagement from knowledge acquisition to community leadership. These badges are carefully designed and issued by the Center for Sustainability to reward sustainable actions, in the format of physical (badge stickers) and digital badges (badges to be displayed on LinkedIn - one of the biggest professional networks). Intrinsically, one is incentivized beyond the satisfaction of knowing individual's eco-actions; extrinsically, the achievement of the action and progress are represented by the token of the badges and the status to be shared through social media.

To facilitate easy navigation and decision-making, AI was employed to analyze each action and add valuable metadata such as impact level, effort required, suitable locations, estimated completion time, and seasonal applicability. This comprehensive organization enables users to more effectively navigate, filter, and discover actions that match their specific contexts and preferences. Actions are positioned within a quadrant framework based on their relative impact and required effort (Figure 1). They are categorized as **"Quick Wins"** (high impact, low effort), **"Big Projects"** (high impact, high effort), **"Easy Habits"** (low impact, low effort), or **"Foundation Work"** (low impact, high effort).

Each action was additionally tagged with relevant United Nations Sustainable Development Goals (SDGs) and subgoals, seasonal applicability, location context, estimated time commitment, and target audience (undergraduate students, graduate students, faculty, staff, or everyone).

2.2 Design of MyEcoPal

MyEcoPal is a web application designed to engage individuals in sustainable behaviors through personalized tracking, feedback, and recommendations. It was implemented using Flutter with a NoSQL database hosted on Firebase.

The app integrates three key functional modules (**Assessment, Engagement,** and **Action**) grounded in behavioral science frameworks (see Figure 2). The system balances comprehensiveness with ease of use while reinforcing theoretical principles of sustainable behavior change.

2.3 User Study

To assess the effectiveness of MyEcoPal, we conducted a user study focusing on both system usability and behavioral impact. A total of 28 participants were recruited from the university campus, including 25 undergraduate students, 1 graduate student, and 2 university staff.

The study employed a pre-survey/post-survey design to measure changes in sustainability awareness and behavior. Pre-study surveys assessed participants' baseline sustainability awareness, current behaviors, and attitudes toward environmental issues. Post-study surveys evaluated changes in sustainability awareness and behaviors, while also assessing system usability through standardized measures including the System Usability Scale (SUS) [3].

Participants were provided with 10 days of access to the MyEcoPal application. System usage data was collected throughout the study period, including frequency of application access, actions browsed, actions completed, carbon calculator usage, and simulator engagement.

3 Evaluations & Results

Table 1: Summary of completed sustainable actions by categories.

Category	Effort	Impact	Actions completed (%)
Quick Wins	Low	High	249 (42.1%)
Easy Habits	Low	Low	228 (38.6%)
Foundation Work	High	Low	85 (14.4%)
Big Projects	High	High	29 (4.9%)
Total			**591 (100%)**

3.0.1 Emphasis on Low-effort, High-impact Actions. Analysis of completed actions revealed a strong preference for lower-effort activities, such as *"Use a reusable bottle"* or *"Utilize outdoor/shared spaces"*. As summarized in Table 1, Quick Wins (high impact, low effort) were the most popular with 249 completions (42.1%), followed

Figure 2: MyEcoPal's user interface. The application is organized into three functional modules: Assessment (carbon footprint calculator and impact visualizations), Action (sustainable behavior repository for discovery and exploration), and Engagement (achievement & progress tracking, interactive simulation). Overlaid numbers indicate theory-guided behavioral constructs: (1) Attitude: instillation through evaluating, simulating, and visualizing the impact of carbon footprint in forest absorption, driving distance and flight emissions; (2) Autonomy: freedom for users to flexibly plan and explore sustainable actions based on their priorities and preferences, enabling personalized sustainability pathways; (3) Competence: immediate feedback through achievement badges, progress visualizations, and carbon emission metrics reflecting personal accomplishments, thereby reinforcing users' sense of efficacy and progress; (4) Relatedness: detail descriptions and recommendations of the sustainable action impact, effort, and the associated SDGs, fostering a sense of connection and collective engagement in users' sustainability journeys.

closely by Easy Habits (low impact, low effort) with 228 completions (38.6%). In contrast, users demonstrated significantly less engagement with high-effort activities: Foundation Work (low impact, high effort) and Big Projects (high impact, high effort) accounted for 85 (14.4%) and 29 (4.9%) completions, respectively. Examples of high-effort actions include *"Serve plant-based meals"* or *"Organize a nature clean-up"*.

The combined total of 477 low-effort actions (80.7% of all actions) compared to 114 high-effort actions (19.3%) highlights the importance of minimizing perceived implementation barriers when designing sustainable interventions. One user wrote in the feedback: *"Most easy actions can be checked off right away - read a website, go thrifting. That was the most fun for me, and a real advantage of the app - the quick win of marking off all the things I already do!"*. This suggests that offering accessible entry points is crucial for initial engagement. Nevertheless, the completion of high-effort actions during the short study period showcases the success of MyEcoPal in promoting commitment beyond simple tasks.

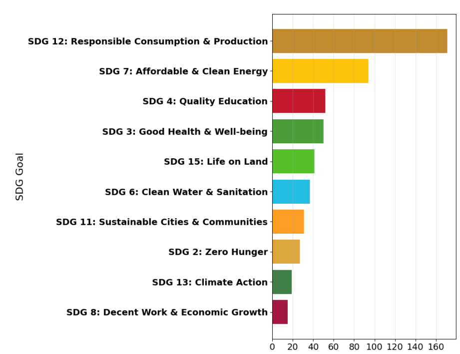

Figure 3: Distribution of completed sustainable actions across United Nations SDGs.

3.0.2 Sustainability Themes of Actions. Figure 3 illustrates the distribution of completed sustainable actions based on the SDGs. Responsible Consumption & Production (SDG 12) dominated user engagement with over 160 completions, followed by Affordable & Clean Energy (SDG 7) with over 90 completions. Quality Education (SDG 4) and Good Health & Well-being (SDG 3) each received moderate attention with over 50 completions. This pattern suggests users may gravitate toward sustainability actions with tangible, personally relevant benefits (e.g., consumption habits, energy savings, education) rather than those perceived as more abstract global challenges. The strong emphasis on consumption-related actions aligns with the finding that users preferred lower-effort activities, as many consumption-based interventions require minimal effort to implement.

The distribution across the SDGs reflects the effectiveness of MyEcoPal in educating users' understanding toward specific sustainability domains, and extends the sustainability exposure to various SDGs. The strong emphasis on consumption-related actions aligns with Section 3.0.1 finding that users preferred lower-effort activities, as many consumption-based interventions (e.g., using reusable items, reducing packaging) typically require minimal effort to implement.

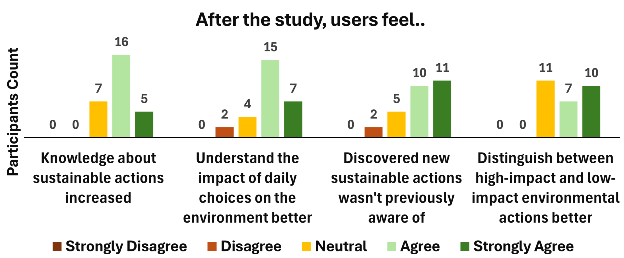

Figure 4: Subjective feedback from users after they completed the study.

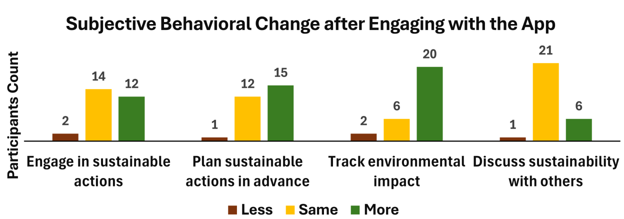

Figure 5: Behavior changes projected by users after the study.

3.0.3 Enhanced Understanding and Behavioral Intent. The post-study survey indicates that the platform successfully enhanced participants' environmental literacy (Figure 4). A strong majority of the 28 users reported that their knowledge about sustainable actions increased (21 of 28), they understood the environmental impact of their daily choices better (22 of 28), and they discovered new actions they were previously unaware of (21 of 28). This knowledge transformation was articulated in detailed feedback from one user: *"Many of the actions suggested in the application were things I had already been doing, such as line-drying clothes, taking short showers, conserving cold water, etc. However, I hadn't recognized these as sustainable actions until using the app."*

In addition, 21 participants agreed that they discovered sustainable actions they weren't previously aware of through the application, and 17 participants reported improved ability to distinguish between high-impact and low-impact environmental actions, which is crucial for effective decision-making regarding sustainable behaviors, enabling users to prioritize actions that yield the greatest environmental benefits. As two participants explained: *"Once I realized their impact, I became more interested in exploring additional sustainability habits that I could incorporate into my routine."* and *"This experience made me more conscious of my daily choices and encouraged me to think about sustainability in new ways".*

This enhanced awareness appears to translate into self-reported behavioral shifts (Figure 5). The most notable changes were in planning and accountability, with 20 of 28 users reporting they tracked their environmental impact more and 15 reporting they planned actions in advance more often. One participant described their process: *"...to track my progress, I added actions to the to-do list and checked them at the end of the day to see which ones I had completed..."*. These findings suggest MyEcoPal successfully provides tools for monitoring and maintaining awareness of sustainability efforts.

The SUS assessment revealed a score of 79 for MyEcoPal, indicating good usability. This high score suggests that participants found the application intuitive, easy to navigate, and learnable without significant barriers [3].

4 Conclusions

This paper introduced MyEcoPal, a web application designed based on behavioral theories to bridge the gap between sustainability knowledge and action. MyEcoPal provides user interfaces to facilitate individuals in calculating personal carbon footprints, visualizing the impact, and exploring "what-if" scenarios through simulations, connecting to actionable steps, and tracking their sustainability journey. MyEcoPal is powered by a novel AI-Augmented Sustainability Action Framework, which supports systematic Impact & Effort organization and evaluation, enabling the application scalability. A user study was conducted to investigate the system usability. The findings demonstrate that MyEcoPal enhanced participants' understanding of environmental impact while supporting sustainable action planning and tracking. The AI-Augmented Sustainable Action Framework effectively guided users toward actionable steps, with participants strongly preferring low-effort interventions (80.7% of actions). User engagement patterns revealed diverse approaches to sustainability, with a preference for actions related to Responsible Consumption and Clean Energy, suggesting users prioritize sustainability domains with immediate personal relevance.

The primary limitation of this study is the small sample size (n=28) drawn from a university setting and brief study duration (10 days) that could limit the generalizability of findings and the ability to observe long-term behavioral change. Besides, the self-reported data could introduce potential bias, suggesting future studies should incorporate objective measures of behavioral change.

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