A Gamified Dashboard for Sustainable Healthy Food: Design of Group Behavior Incentives and Social Collaboration

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Abstract—**With growing attention to sustainability and public health, helping people adopt healthier, eco-friendly diets in daily life remains challenging. Most digital health tools focus on individual tracking and lack long-term incentives and social interaction, leading to low engagement and limited behavior change. This study proposes "GreenEat Family," a gamified dashboard that integrates group-based incentives and social collaboration to help families and communities improve dietary health and sustainability together. We built a dual-index food database (Health & Nutrition Index; Environmental Impact Index) and designed an incentive system using virtual rewards ("GreenLeaves") and achievement badges. Social features — including family challenges, community leaderboards, and experience sharing—enhance belonging and collective motivation. In an 8-week study (N=92), compared with a traditional tracking app, the experimental group showed higher sustainable diet knowledge ($p<0.01$), improved diet health index (+18.5%, $p<0.05$), and reduced negative environmental impact (−22.3%, $p<0.05$), with significantly greater usage frequency and duration, indicating strong potential for sustained behavior change.**

Keywords—Gamification Design, Sustainable Diets,Behavioral Incentives, Social Collaboration, Family Nutrition Management,Human-Computer Interaction

I. INTRODUCTION

The global food system is facing unprecedented dual pressure. On one side, unhealthy dietary patterns are a major driver of chronic non-communicable diseases (NCDs), imposing a substantial burden on population health worldwide [1]. The World Health Organization further reports that overweight and obesity remain highly prevalent globally, reflecting the scale of diet-related health risks [2]. On the other side, food production, processing, transport, and consumption are responsible for roughly one-third of global anthropogenic greenhouse gas emissions (GHGEs), highlighting the environmental urgency of shifting dietary practices [3].

In this context, the family—both the basic unit of society and the primary setting for everyday food consumption—plays a decisive role in shaping outcomes related to health and environmental sustainability. Yet within today's complex food environment, many households struggle to make choices that balance nutrition and environmental impact. Common barriers include limited knowledge, high decision complexity, and a lack of timely feedback and sustained motivation. Although mobile health (mHealth) apps have proliferated and often provide nutrition facts or calorie tracking, they still face clear limitations. First, many tools implicitly treat dietary management as an individual activity and underutilize the social influence and collaborative potential within families and neighborhoods. Second, these apps frequently depend on user self-discipline and provide weak long-term incentive structures, contributing to engagement drop-off after initial novelty fades. Third, few platforms integrate both health and environmental metrics into a unified decision framework, leaving users without a coherent basis for daily trade-offs.

To address these gaps, this study asks: How can a digital intervention be designed to effectively motivate and support families in adopting sustainable, healthy dietary patterns over time? We argue that combining the engagement of gamification, the group dynamics of social collaboration, and the reinforcement logic of behavioral science offers a promising approach. Gamification elements—such as points, badges, and leaderboards—can turn routine tracking tasks into meaningful challenges, strengthening motivation and participation. Social collaboration—through family teams, community competitions, and shared goals—can activate peer influence, mutual accountability, and collective pride, shifting dietary change from an individual effort to a shared practice.

- Building on this perspective, we design, develop, and evaluate a dashboard system called "GreenEat Family," tailored specifically to household users. The system contributes through innovations across three levels:
- Integrated Dual-Index Evaluation: a unified model that assesses both the health/nutritional value and the environmental sustainability impact of foods, offering an intuitive basis for everyday decision-making.
- Compound Incentive Framework: a gamified motivation system combining immediate feedback, virtual rewards, achievements, and personalized goals to support long-term engagement.
- Group-Centered Collaborative Interaction: social features such as family teams, community leaderboards, cooperative tasks, and experience sharing that encourage collective motivation and group intelligence.

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Ultimately, this study aims to test whether this integrated paradigm—uniting gamification, social design, and behavioral incentives—can improve families' knowledge of sustainable healthy diets, enhance real-world food choices, and strengthen long-term user engagement. The remainder of this paper is organized as follows: Section 2 reviews related literature; Section 3 presents the system design and technical architecture; Section 4 describes the study design and analysis methods; Section 5 reports results; Section 6 discusses implications and significance; and Section 7 concludes with limitations and future directions.

II. Related Work

This research draws on several cross-disciplinary areas, including sustainable diets, gamification for behavior change, and computer-supported cooperative work (CSCW). Prior work has established that dietary choices are tightly coupled with environmental impacts across food supply chains [4], and has proposed scientifically grounded targets for diets that support both human health and planetary boundaries [5]. At the same time, the relationship between "healthy" and "environmentally sustainable" diets is not always aligned, creating practical tensions in everyday decision-making [6]. Evidence from health psychology further indicates that social support is a critical determinant of sustained health behavior and related disease outcomes [7], while online social interaction patterns can shape (and sometimes complicate) real-world relationships and engagement [8]. Within human–computer interaction, gamification has been formalized as the use of game design elements in non-game contexts [9], with accumulating empirical evidence—across domains—on when gamification does or does not improve engagement [10]. Finally, systematic evidence suggests that interventions leveraging online social networks can be effective for health behavior change, underscoring the importance of socially mediated mechanisms in digital intervention design [11].

A. Digital Interventions for Sustainable Healthy Diets

Interest in sustainable healthy diets has grown rapidly, supported by both environmental life-cycle evidence on food-system impacts [4] and normative dietary frameworks connecting nutrition with planetary limits [5]. However, translating such guidance into everyday action remains challenging, partly because "healthy" and "sustainable" do not always coincide in practice [6].

To operationalize sustainable-healthy decision-making, researchers have begun developing digital tools that present combined health and environmental signals at the point of choice. For example, Agyemang et al. designed and developed a dashboard that supports more sustainable and healthy food choices by presenting interpretable health-related and environmental indicators to users in a dining decision context [12]. Beyond diet-specific tools, evidence from real-world implementation research shows that sustaining behavior-change interventions over time is difficult, with adoption and long-term maintenance often emerging as key failure points if not designed for explicitly [13].

A further challenge is measurement: sustainable diets are multi-dimensional, and reviews of measurement approaches highlight heterogeneity in indicators and trade-offs, which can undermine comparability and user comprehension if systems provide fragmented signals [14]. In response, this study builds an integrated dual-index evaluation model and embeds it into a dashboard designed to reduce decision friction while maintaining interpretability for household users.

B. Gamification Design for Behavior Change

Gamification is commonly defined as using game design elements in non-game contexts [9]. Its motivational logic is often grounded in self-determination theory, which emphasizes psychological needs such as autonomy, competence, and relatedness as drivers of intrinsic motivation and well-being [15]. In health and well-being contexts, systematic reviews indicate that gamification can improve engagement and support behavior change, while also documenting variability across designs and populations [16][17].

Importantly, effective gamification is not equivalent to merely adding points, badges, and leaderboards. Design approaches that foreground meaningful skill development and long-term engagement caution against superficial "PBL-only" implementations and emphasize alignment with user goals and context [18]. Accordingly, GreenEat Family goes beyond basic reward mechanics by integrating personalized challenges, progress feedback, and team-based collaboration, with the intent to support more durable dietary change rather than short-lived novelty effects.

C. Social Collaboration for Promoting Health Behaviors

Social support theory identifies family, friends, and community networks as essential resources for maintaining positive health behaviors and buffering stress, with documented links to health-relevant physiological processes and outcomes [7]. In digital contexts, online interaction patterns can influence offline relationship quality and engagement, making social design a consequential factor in intervention effectiveness [8]. Evidence syntheses further suggest that health behavior change interventions leveraging online social networks can be effective, supporting the inclusion of collaborative and socially mediated mechanisms as core—not peripheral—features [11].

In family-centered health contexts, structured family support interventions are being formally evaluated for chronic disease management, reflecting the field's recognition that household dynamics can meaningfully shape adherence and outcomes [19]. Despite this, many mainstream diet apps treat social functions as optional add-ons rather than as primary drivers of collective action. A central contribution of this study is to position social collaboration as a first-class design goal through family teams, community leaderboards, collaborative tasks, and peer sharing—reframing individual food choices as shared efforts that may strengthen accountability and long-term retention.

D. Summary

Overall, this study is not a minor refinement of existing tools, but a deliberate integration of sustainability science, measurement-informed dual-index modeling, human-centered gamification, and social collaboration into a digital intervention tailored for family contexts. Through the design and evaluation of GreenEat Family, we contribute design knowledge and empirical evidence on how technology can better support long-term adoption of sustainable, healthy dietary practices.

III. "GREENEAT FAMILY" SYSTEM DESIGN AND METHODS

To achieve our research objectives, we adopted a "human-centered" design philosophy, combining theoretical research with user needs analysis to design and develop the "GreenEat Family" dashboard system. This chapter will detail the system's overall architecture, the design principles of its core functional modules, and their implementation methods.

A. System Architecture

The "GreenEat Family" system uses a front-end/back-end separated B/S architecture, ensuring cross-platform accessibility (Web, mobile browsers) and flexibility for future expansion. The overall architecture of the system, as shown in Figure 1, consists of four core components: the Data Layer, the Model Layer, the Application Service Layer, and the User Presentation Layer.

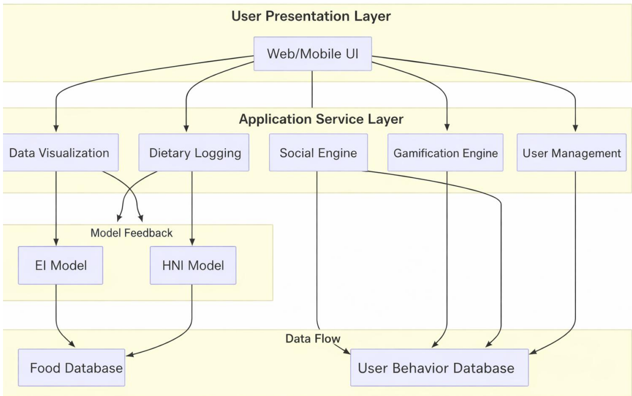

Fig. 1. System Architecture of the GreenEat Family Dashboard

Data Layer: As the system’s foundation, the data layer includes two core databases. The first is a Food Composition and Environmental Factor Database, which consolidates information from authoritative sources such as the China Food Composition Tables, USDA FoodData Central, and Ecoinvent. It contains macronutrient and micronutrient profiles for over 1,000 commonly consumed foods, along with key production-stage environmental indicators such as carbon footprint, water footprint, and land use. The second is a User Behavior Database, which stores continuously updated data including user profiles, dietary logs, social interactions, and gamification progress (e.g., rewards and badges).

Model Layer: Acting as the “brain” of the system, the model layer processes and interprets data through two algorithmic components: the Health & Nutrition Index (HNI) model and the Environmental Impact Index (EII) model. Together, these models convert raw nutritional and environmental values into clear, user-friendly scores that operationalize the system’s dual-index evaluation approach.

Application Service Layer: This layer implements the system’s core business logic, covering user management, food logging, analytics and visualization services, as well as two key functional modules: a gamification engine and a social engine. The gamification engine manages points, badges, progress tracking, and leaderboards, while the social engine enables family team formation and community engagement through shared activities and interaction features.

User Presentation Layer: As the interactive front-end, the system adopts responsive web design to ensure a consistent experience across devices and screen sizes. The interface prioritizes simplicity, clarity, and positive reinforcement, using visual dashboards, charts, and gamified elements to present complex dietary information in a more engaging and accessible manner.

B. Core Functional Module Design

1) Dual-Index Evaluation Model

To provide users with comprehensive and balanced decision support, we designed two core evaluation models: the Health & Nutrition Index (HNI) and the Environmental Impact Index (EII).

Health & Nutrition Index (HNI): This model is adapted from internationally established nutrition scoring systems (like Nutri-Score) and localized according to the Chinese Dietary Guidelines. The HNI calculation considers both "favorable" and "unfavorable" components of food. Unfavorable components include energy density, total fat, saturated fat, sugar, and sodium; favorable components include protein, dietary fiber, the proportion of vegetables, fruits, and nuts, and various vitamins and minerals. For every 100 grams or 100 milliliters of food, we calculate an initial score based on the content of these components, then weight and adjust it according to preset rules, finally generating a continuous score from -15 (least healthy) to +40 (most healthy). To make it easy for users to understand, we map this score to five grades from A (dark green) to E (dark red), similar to a traffic light system, providing intuitive visual guidance.

Environmental Impact Index (EII): This model is primarily based on the Life Cycle Assessment (LCA) methodology. We selected three core indicators that are crucial to the global ecosystem: carbon footprint (in CO_2 equivalent/kg of food), water footprint (in liters/kg of food), and land use (in square meters/kg of food) . We standardized the data for these three indicators for each food item in our database (min-max normalization), then assigned different weights based on expert recommendations (carbon footprint: 50%, water footprint: 30%, land use: 20%), and calculated a weighted average to obtain a comprehensive environmental impact score. Similarly, we mapped this score to five grades from A to E, with Grade A representing the most environmentally friendly.With these two models(Fig 1 and 2), when users record or look up a food item, they can see its rating on both health and environmental dimensions simultaneously, allowing them to make more informed trade-offs. For example, a user might find that beef, while rich in protein (possibly rated B on HNI), comes at a huge environmental cost (rated E on EII), whereas lentils perform excellently on both dimensions (HNI=A, EII=A)(Figure 2).

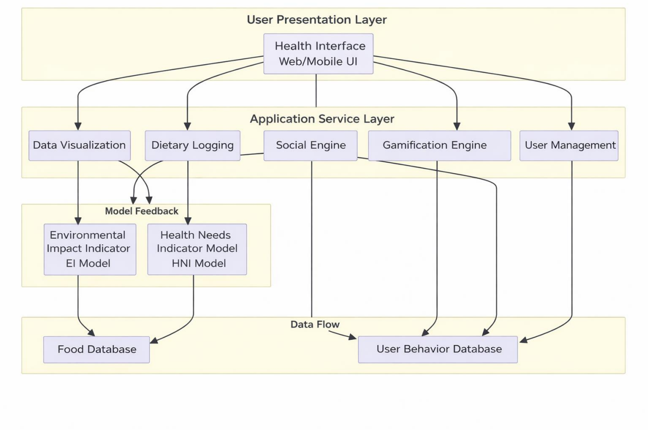

Fig. 2. The Dual-Index Evaluation Model for Food Assessment

2) *Gamification Incentive Engine*

To enhance long-term user engagement, we designed a multi-layered gamification incentive engine, with "GreenLeaves" virtual reward system at its core.
GreenLeaves System: Each time a user records a meal, the system rewards them with a certain number of "GreenLeaves" based on the meal's composite HNI and EII scores. The higher the score, the more rewards. This immediate, quantified positive feedback effectively reinforces users' positive behaviors. Accumulated "GreenLeaves" can be redeemed for rewards in the system's virtual store, such as unlocking new healthy recipes, personalized avatar customizations, or even real discounts at partnered organic farms or supermarkets, thus connecting online incentives with offline value.

Achievement and Badge System: In addition to "GreenLeaves," the system features over 50 different achievement badges to encourage users' diverse explorations and continuous efforts. These badges are divided into different categories, such as:

Habit Formation: "Three Meals a Day," "One Week Streak," "Veggie Pioneer," etc., to encourage regular recording and trying healthy diets.

Knowledge Exploration: "Erudite," "Nutrition Master," obtained by completing quizzes on sustainable healthy eating.
Social Butterfly: "Family Core," "Community Star," obtained through active social interaction.

Special Challenges: "Clean Plate Hero," "Water Saving Guardian," obtained by completing specific environmental challenge tasks.(Fig 3).Personalized Goals and Challenges: To avoid a "one-size-fits-all" design, the system allows users to set personalized weekly goals based on their own situations, such as "try three vegetarian dinners this week" or "reach 1.5 kg of fruit intake this week." The system provides feedback and rewards based on the user's goal completion. In addition, the system regularly releases community-wide, time-limited challenge events, such as "Red-Meat-Free Week." Family teams that successfully complete challenge receive a large number of "GreenLeaves" and exclusive team honor badges.

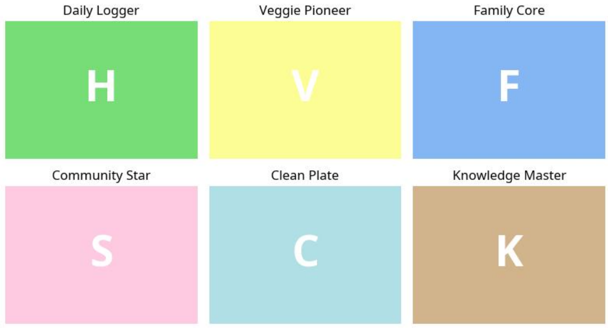

Fig. 3. Sample achievement badges

3) *Social Collaboration Engine*

Social collaboration is another major pillar of the "GreenEat Family" system design, aimed at amplifying the effect of behavior change through group dynamics.

Family Team Function: Users can invite family members to form a "family team." Within the team, members can see each other's dietary records (with privacy settings), earned "GreenLeaves," and achievements. The system calculates the entire family's average HNI and EII scores and presents the family's overall progress in a weekly report. This design aims to promote mutual encouragement, healthy competition, and joint planning within the family, turning individual health goals into a common family cause.(Fig 4)

Community Leaderboard and Dynamic Sharing: All family teams are ranked on an anonymous community leaderboard based on the total number of "GreenLeaves" they earn each week. The leaderboard is divided into multiple dimensions such as "Rising Star of the Week" and "Most Improved," aiming to stimulate friendly competition and a sense of collective honor among teams. At the same time, users can share photos of their healthy meals, cooking tips, or success stories on a social media-like dynamic feed, and like and comment on others' shares. This exchange of experiences not only disseminates knowledge but also builds a supportive community atmosphere.Collaborative Tasks: The system regularly releases collaborative tasks that require multiple families to complete together, such as a "community cumulative water saving goal for the week" or "cumulatively planting virtual trees." When the community collectively achieves the goal, all participants receive generous rewards. This design aims to cultivate users' sense of Collective Efficacy, allowing them to feel that their small contributions converge into a huge collective force.

Through the organic combination of these three core modules, the "GreenEat Family" system builds a complete behavior change support loop from "information acquisition" to "motivation stimulation" to "social support," providing an innovative solution for guiding families to adopt sustainable healthy diets.

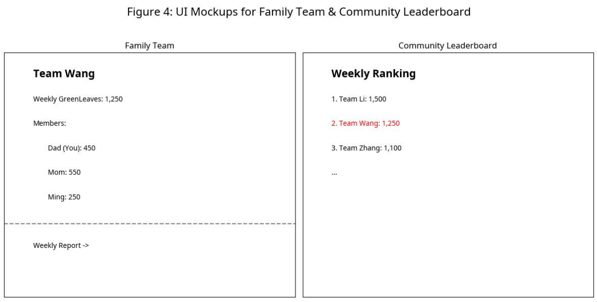

Fig. 4. User Interface Mockups for the Family Team & Community Leaderboard

IV. Experimental Design and Data Analysis

To evaluate the effectiveness of GreenEat Family in a scientific and rigorous way, we conducted an 8-week randomized controlled trial (RCT).

A. Study Participants

Participants were recruited via social media, community noticeboards, and partner channels (e.g., health-related public accounts). Inclusion criteria were: (1) 18–65 years old; (2) living with at least one family member and regularly sharing meals; (3) owning and being able to use a smartphone or computer; (4) willing to improve dietary health. Exclusion criteria were: (1) currently receiving professional nutrition therapy; (2) having a serious illness that affects normal eating; (3) having used other diet-logging apps for more than one month. All participants provided informed consent, and the protocol was approved by the university ethics committee.Informed consent was obtained from all subjects involved in the study.

In total, 105 eligible participants were enrolled and randomly assigned (computer-generated sequence, 1:1) to the experimental group (n=53) or control group (n=52). During the trial, 4 participants in the experimental group and 7 in the control group withdrew, yielding 94 valid participants (49 experimental; 45 control). Baseline demographics (age, gender, education, income) and initial dietary habits did not differ significantly between groups (all $p>0.05$), supporting comparability.

B. Study Procedure

The study consisted of three phases: baseline (Week 0), intervention (Weeks 1–8), and post-test (end of Week 8) (Fig 5).

Experimental group: Participants installed and used GreenEat Family. They received a 30-minute online onboarding covering meal logging, viewing HNI/EII scores, creating family teams, and joining challenges. Throughout Weeks 1–8, they were asked to log daily meals as completely as possible and could freely use all gamification and social features.

Control group: Participants used a commercial diet-recording app with basic functions only (food database and nutrient logging such as calories, protein, fat, carbohydrates), without gamification, social features, or composite scoring. They received usage training and logged meals for 8 weeks.

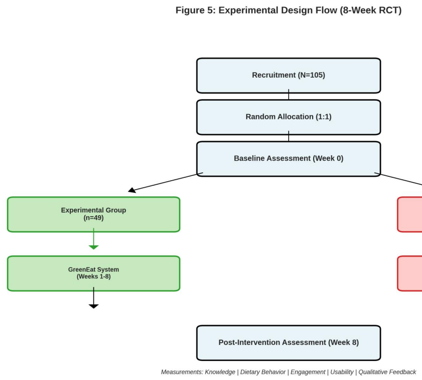

Fig. 5. Experimental Design Flow (8-Week RCT)

C. Measurement Metrics

We assessed outcomes across knowledge, behavior, and engagement/usability.

1) Knowledge of sustainable healthy diets: At baseline and post-test, participants completed an expert-validated questionnaire (20 multiple-choice items) covering nutrition basics, food carbon footprints, and balanced meal composition. Total score: 20.

2) Dietary choice behavior (primary outcome): Using logged dietary data from Weeks 1–8, we computed:

- Average daily HNI (overall dietary health level)
- Average daily EII (overall environmental friendliness)
- Food-category intake frequency, including red meat, processed foods, vegetables, fruits, and legumes
- User engagement and usability:
- Usage logs: login frequency, average session duration, and feature interactions (e.g., leaderboard views, posting)
- System Usability Scale (SUS): completed at Week 8; 10 items, total score 0–100, widely used for usability evaluation.
- User interviews: 12 experimental-group participants were randomly selected for semi-structured interviews on overall experience, perceptions of gamification/social features, and perceived drivers of behavior change

D. Data Analysis Methods

Quantitative analyses were conducted in SPSS 26.0. We reported descriptive statistics (mean, SD). Intervention effects on baseline vs. post-test outcomes were tested using Repeated Measures ANOVA (group × time interaction). Between-group differences in behavioral and engagement metrics during the intervention were examined with independent-samples t-tests. For categorical outcomes (e.g., intake frequency categories), chi-square tests were used. Statistical significance was set at $\alpha = 0.05$.

Interview data were analyzed with Thematic Analysis. Two researchers independently coded transcripts to identify themes and patterns, then resolved discrepancies through discussion to strengthen reliability and validity.

V. Results and Discussion

This chapter reports the core findings from the experimental design and analyses described above, covering knowledge, behavior, engagement, and subjective experience.

A. Improvement in Knowledge of Sustainable Healthy Diets

Repeated-measures ANOVA showed a significant group × time interaction on knowledge scores ($F(1,92)=18.65$, $p<0.001$, $\eta^2=0.169$). At baseline, the experimental group ($M=11.2$, $SD=2.8$) did not differ from the control group ($M=10.9$, $SD=2.9$) ($p>0.05$). After 8 weeks, the experimental group increased to 15.8 ($SD=2.5$; +41.1%), while the control group rose slightly to 11.7 ($SD=3.0$; +7.3%). Post-test scores differed significantly ($t(92)=7.24$, $p<0.001$) (Fig 6).

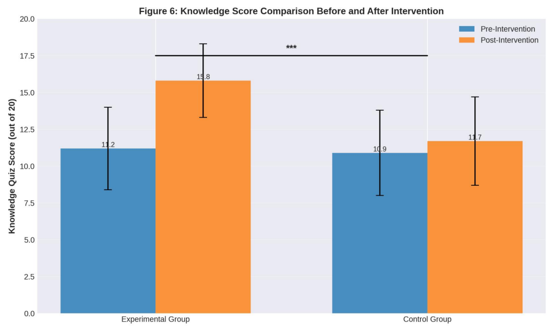

Fig. 6. Knowledge Score Comparison Before and After Intervention

B. Improvement in Dietary Choice Behavior

Across the 8-week intervention, we analyzed 39,480 dietary records. Independent-samples t-tests indicated that the experimental group achieved significantly healthier and more sustainable choices than the control group.

HNI: Experimental group mean HNI was 12.5 ($SD=4.1$), higher than the control group's 10.2 ($SD=4.5$) ($t(92)=2.89$, $p=0.005$), suggesting more nutritious selections.EII: Because EII is a negative indicator (lower is better), the experimental group's mean EII was -8.9 ($SD=3.8$), lower than the control group's -6.7 ($SD=4.2$) ($t(92)=-2.91$, $p=0.004$), indicating lower environmental burden (Fig 7).

Food-category trends reinforced these effects. By Week 8, the experimental group increased vegetables/fruits by 35% ($p<0.01$) and legumes/bean products by 52% ($p<0.001$), while reducing red meat by 28% ($p<0.05$) and sugary drinks by 45% ($p<0.01$). The control group showed no statistically significant changes (Fig 8).

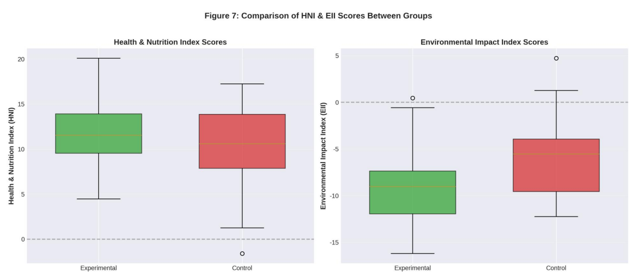

Fig. 7. Comparison of HNI & EII Scores Between Groups

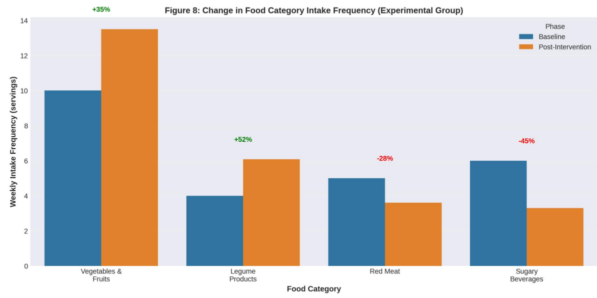

Fig. 8. Change in Food Category Intake Frequency (Experimental Group)

C. User Engagement and System Usability

Backend logs showed higher engagement in the experimental group:

- Login frequency: 5.8 vs. 3.1 times/week ($t(92)=6.45$, $p<0.001$)
- Session duration: 8.2 vs. 3.5 minutes ($t(92)=7.11$, $p<0.001$)

Usability results were also stronger. The experimental group's SUS score for GreenEat Family was 85.4 ($SD=8.2$), well above the typical benchmark (68) and in the "excellent" range. The control app scored 65.7 ($SD=10.1$), around "acceptable." The difference was significant ($t(92)=10.18$, $p<0.001$) (Fig 9).

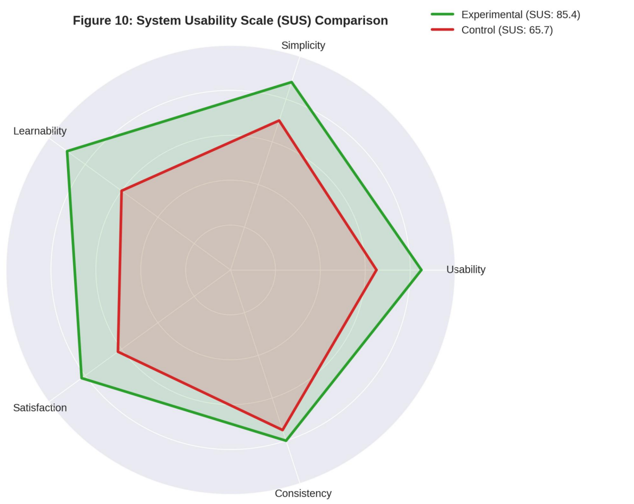

Fig. 9. System Usability Scale (SUS) Comparison

D. User Subjective Experience (Qualitative Results)

Interviews with 12 experimental participants revealed three themes aligned with the quantitative findings:

Theme 1: Gamification makes "health" enjoyable and doable.
Participants described GreenLeaves and badges as clear goals with immediate satisfaction. Personalized challenges helped them progress gradually rather than making abrupt changes.

Theme 2: Family teams shifted diet change from "my task" to "our project." Users valued that individual meals affected the family's shared progress and ranking, creating "team honor," more discussion about meals, and mutual encouragement—leveraging close-tie accountability.

Theme 3: The community provided motivation, support, and learning.Leaderboards created friendly competition, while the feed enabled recipe exchange, practical tips, quick Q&A, and a sense of not changing habits alone.

Together, the qualitative and quantitative evidence suggests GreenEat Family outperforms traditional logging tools in knowledge gains, behavior change, and sustained engagement — largely due to its gamified incentives and social collaboration design.

Building on these results, the remainder of this chapter interprets the findings and discusses theoretical and practical implications.

E. *Synergistic Effect of Gamification and Social Design*

A key contribution is the synergy between gamification and social mechanisms. Gamification supports competence and autonomy through immediate feedback (GreenLeaves), goal-setting (personal challenges), and accomplishment (badges), turning routine logging into a motivating "progress" experience — consistent with Self-Determination Theory. Yet gamification alone may fade over time. The novelty here is deep social integration: family teams tie individual choices to shared honor, adding social responsibility and peer influence; community leaderboards extend recognition and status beyond the household. Users repeatedly described the shift from "I" to "we" as central to sustained change. In effect, the system forms a reinforcing loop of fun → purpose → belonging → responsibility.

F. *Value and Challenges of the Dual-Index Evaluation System*

The HNI+EII dual-index provides an integrated view that typical calorie- or nutrient-only tools cannot. By using intuitive A–E ratings, users can see trade-offs clearly (e.g., beef may rate well on HNI but poorly on EII, while lentils can score high on both). This transparency likely contributed to the observed knowledge gain (+41.1%) and behavioral shifts (higher HNI, lower EII).

However, dual-index systems face practical challenges: (1) data quality and localization are costly, since nutrition and environmental impacts vary by origin, processing, and season; (2) model validity and fairness require continuous testing and updates. For example, the EII weights (50/30/20 for carbon/water/land) are literature- and expert-informed but not universal; future work could refine weights and add dimensions such as biodiversity loss. Even so, an integrated, explainable framework remains a promising direction for empowering responsible choices.

G. *Comparison with Existing Research*

Compared with the DISH dashboard, GreenEat Family advances in two ways: it targets the more complex home setting (purchasing, cooking, varied options) and makes family interaction a core design element rather than an individual decision aid. It also uses a richer incentive structure than DISH (virtual currency, badges, personalized challenges, team honor) and binds incentives to social features, which likely supports stronger engagement and behavior change.

Compared with commercial success stories like Fitbit, this work extends gamified intervention from physical activity to the more complex domain of diet, and systematically incorporates environmental sustainability as a first-class metric—broadening the scope of gamified digital health toward societal sustainability goals.

H. *Limitations and Future Directions*

Several limitations remain. First, although randomized, participants were volunteers and may have been more health-motivated than the general population, limiting generalizability; future studies should test more diverse groups across cultures and socioeconomic backgrounds. Second, while 8 weeks was sufficient to detect changes, longer follow-ups (6–12 months) are needed to assess durability and potential incentive decay over time.

Third, the current system relies largely on manual logging, which can be burdensome and error-prone. Future iterations could incorporate AI (e.g., photo-based meal recognition and portion estimation) and integrate with smart devices or shopping platforms to reduce effort and improve accuracy.

Finally, this study focused mainly on outcomes; deeper psychological mechanisms warrant further work. Future research could incorporate theories such as the Theory of Planned Behavior or Social Cognitive Theory, and use dismantling designs to isolate the effects of specific gamified and social components.

VI. CONCLUSION

This study targeted two persistent problems in digital health tools for sustainable healthy diets: low engagement and weak long-term impact. By tightly combining gamified incentives with social collaboration, we designed, built, and tested a family-focused dietary dashboard, GreenEat Family. In an 8-week randomized controlled trial, the system outperformed a conventional diet-logging app by significantly improving users' sustainable-diet knowledge, steering choices toward healthier and more eco-friendly foods, and raising engagement and satisfaction.

Our main contribution is a practical design paradigm for digital health interventions: embedding personal health goals in an enjoyable game-like structure and a supportive social network can better spark — and sustain — motivation for behavior change. The findings suggest future tools should move beyond information display and solo tracking toward integrated environments that meet intrinsic needs and enable group action.

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Meiqin Cai: Conceptualization; Methodology; Investigation; Data Curation; Validation; Writing – Original Draft; Writing – Review & Editing; Supervision; Project Administration.

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COMPETING INTERESTS

The authors declare no competing interests.