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The Food Waste Score: Just-In-Time Feedback for Reducing Campus Food Waste

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Food waste is a persistent challenge in all-you-can-eat university (AYCE) dining halls, where diners face few incentives to avoid over-serving. We present the Food Waste Score (FWS), a just-in-time feedback system that translates discarded food into a simple 0–100 score and delivers immediate, personalized feedback at the moment waste occurs. We deployed the FWS for two weeks in an AYCE university dining hall (N = 23) and evaluated usability and perceived behavioral impact through surveys and open-ended responses. Participants rated the system as highly usable (SUS M = 85.1) and reported increased awareness of personal food waste (M = 4.65) and strong perceived impact of just-in-time feedback (M = 4.39). Qualitative themes suggest that immediate feedback encouraged reflection and smaller initial portions, while social comparison features produced mixed reactions. These findings highlight the promise of individualized eco-feedback systems for motivating reduced food waste in shared dining spaces.

CCS Concepts: • **Human-centered computing → User studies**.

Additional Key Words and Phrases: food waste, eco-feedback, just-in-time feedback, sustainability, user studies, gamification

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1 Introduction

Food waste in university dining halls is a major environmental challenge in the U.S. In all-you-can-eat (AYCE) environments, consumers face little immediate cost for taking more food than they consume, thereby eliminating financial incentives to reduce waste. At large campuses, tens of thousands of pounds of edible food are discarded daily, creating unnecessary environmental and ethical costs [5]. Prior work shows that electronic nudges [17], posters [4], and aggregate feedback [9] can reduce food waste in these settings. However, many interventions rely on impersonal or delayed information, making it difficult for individuals to connect their behavior to waste outcomes.

This paper explores whether just-in-time, personalized feedback can inspire more mindful dining habits. We introduce the *Food Waste Score* (FWS), a prototype that provides students with immediate, personalized feedback when they discard uneaten food. The FWS transforms food waste into a user-friendly score from 0 to 100, shares targeted advice,

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and invites students to join a dining hall leaderboard. By turning waste into a gamified challenge, the system makes food waste visible and personally meaningful.

Our work builds on prior eco-feedback and gamification research in dining contexts, but shifts the focus to individual accountability and interpretation. Rather than displaying aggregate statistics or generic reminders, the FWS ties each meal's waste to an immediate performance signal. The system integrates into existing dining hall routines with minimal effort while respecting voluntariness and privacy. From an HCI perspective, this work examines how interface features such as scoring and real-time comparison shape reflection during everyday decisions.

We built the FWS as a web-based system connected to a digital scale and piloted it in an AYCE university dining hall for two weeks. Our evaluation captured usability, awareness, and perceived behavioral change through surveys and qualitative feedback. Results suggest that personalized, just-in-time feedback increases awareness of personal food waste and may reduce discarded food.

2 Related Work

Food waste remains a persistent problem in AYCE university dining halls, where diners face few immediate incentives to avoid over-serving [5, 17]. Prior research shows that structural interventions—such as removing trays, using smaller plates, and controlling portion sizes—can substantially reduce waste at scale [8, 12]. However, these approaches primarily modify the dining environment rather than influencing individual decision-making. Behavioral studies further suggest that while personal values shape food conservation, buffet-style dining increases the tendency to take extra food "just in case," weakening the link between values and action [16]. Together, this work motivates approaches that target individual behavior.

A substantial body of work demonstrates that feedback and nudging strategies can reduce food waste in dining settings. Physical nudges such as posters and signage have reduced waste by up to 40% in university dining halls [4], and digital displays have shown similar effects in student housing [9]. While effective at increasing awareness, these interventions typically provide aggregate feedback, limiting individualized learning or sustained behavior change. More personalized nudges, such as SMS messages, have shown stronger effects on students' food knowledge, attitudes, and waste behaviors by reaching individuals directly [10]. Systems like PittGrub further demonstrate the value of personalization by using data-driven notifications to redirect surplus food to nearby students [15]. Despite these advances, most feedback-based interventions do not link feedback to a diner's own waste in real time.

Recent advances in sensing technologies have enabled accurate measurement of food waste in cafeteria environments. Four studies using smart bins and sensor-equipped self-serve lines show that a small subset of diners accounts for a disproportionate share of plate waste [6, 7, 11, 19]. The insights from these studies agree that although these systems provide valuable tools for institutional monitoring, they rarely translate measurements into user-facing feedback. As a result, diners receive little actionable information about how their own actions contribute to waste. FoodWise partially addresses this gap by combining a campus-wide dashboard with individual logging, but its feedback remains largely aggregate and delayed [18].

HCI research suggests that eco-feedback is most effective when it is timely, interpretable, and delivered at moments of decision-making [13]. Personalized scores and coaching (common in fitness and wellness technologies) support behavior change by encouraging reflection and progress tracking [3]. Gamification elements such as scores and leaderboards can further sustain engagement when feedback emphasizes individual performance [14]. Building on these insights, the FWS integrates waste measurement with personalized, meal-level feedback delivered immediately after disposal, addressing limitations of prior approaches that focused on structure, aggregate data, or sensing alone.

3 System Implementation

We designed the FWS as an easily deployable tool within existing dining hall workflows. It integrates physical sensing hardware with a web-based interface and backend services to capture food waste events, compute personalized scores, and deliver immediate feedback.

A user approaches the waste disposal area with a dish of food waste, where a digital scale and a computer displaying the FWS interface are positioned nearby (Figure 3). Users place their dish on the scale, enter their unique ID, and select a dish type (plate, salad bowl, or cereal bowl) corresponding to the dining hall's available dishes (Figure 4). This selection allows the system to subtract the appropriate tare weight. The system then computes and displays a personalized FWS, a statement indicating whether the score increased or decreased relative to the previous meal, and a brief encouragement (Figure 5). Users may optionally add their result to a dining hall leaderboard using three self-selected initials (Figure 6).

We measured food waste weight with a DYMO Digital Postal/Shipping Scale connected via USB, which enumerates as a Human Interface Device (HID). A laptop at the disposal station served as both the display terminal and backend host. We implemented the frontend in React and the backend in Flask (Python 3.9.6) using the `hidapi` library. All data were stored in a PostgreSQL database. The Python backend mapped discarded food weight to an intuitive 0–100 score using an exponential decay function that penalizes waste above an average baseline weight while remaining stable for small deviations (Appendix B). Only users who had signed a consent form could use an ID within the system. Leaderboard entries were stored separately using user-chosen initials, ensuring that public displays did not reveal personal identities.

4 Evaluation

4.1 Participants

We recruited 23 Princeton University students, all members of Tiger Inn, a club with an AYCE dining hall at Princeton University. All participants provided informed consent prior to the study.

4.2 Procedure

We conducted a within-subjects study over two weeks, which was appropriate given our sample size. Each time participants logged into the FWS, they were randomly assigned to either treatment A (score and leaderboard) or treatment B (no score or leaderboard). Participants were introduced to the system at the beginning of the study and instructed to weigh their dishes after meals. All interactions (dish type, weight, score, timestamp) were logged automatically. At the end of the study, participants completed a post-study questionnaire (Appendix C).

The questionnaire measured system usability, perceived motivational and behavioral impact, and qualitative feedback. We administered the 10-item System Usability Scale (SUS), with responses on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Additional Likert-scale items assessed: (1) awareness of personal food waste, (2) importance of reducing food waste, (3) intention to reduce food waste, (4) impact of just-in-time feedback (treatment A) relative to no feedback (treatment B), (5) usefulness of the personalized score, and (6) usefulness of the public leaderboard. Participants also responded to four open-ended questions about their experience, perceived changes, and suggestions for improvement.

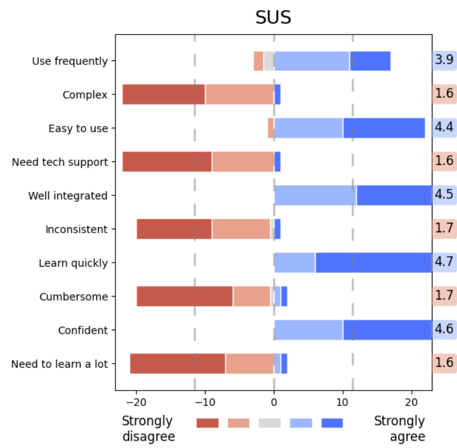

Fig. 1. Distribution of Likert-scale responses for System Usability Scale (SUS) items. Diverging bars show the proportion of responses from strongly disagree (left) to strongly agree (right). Numbers indicate mean item ratings on a 1–5 scale. Odd-numbered items reflect positive usability statements, while even-numbered items reflect negative usability statements.

4.3 Results

We analyzed quantitative data descriptively using means and standard deviations. We excluded one participant from the SUS analysis due to an incomplete questionnaire, resulting in $N = 22$ for usability results. We computed SUS scores following the standard procedure, yielding values from 0 to 100. The reported SUS score reflects the mean across participants. We analyzed qualitative data using thematic analysis [2]. Responses were reviewed to identify recurring ideas, grouped into themes, and illustrated with representative quotes.

4.3.1 SUS. The FWS received high usability ratings ($M = 85.1$, $SD = 11.94$), corresponding to an "Excellent" rating on Bangor et al.'s adjective scale [1]. Figure 1 summarizes responses to individual SUS items, showing consistently positive usability perceptions across the scale. SUS-adjusted scores in Table 1 indicate that the system was rated as particularly learnable (Item 7, $M = 3.73$) and that users reported high confidence in use (Item 9, $M = 3.59$).

4.3.2 Motivational and Behavioral Impact. As shown in Figure 2, participants reported the strongest effects for increased awareness of personal food waste ($M = 4.65$) and the impact of including just-in-time feedback as opposed to receiving no feedback ($M = 4.39$). Ratings for the personalized score ($M = 4.05$) and leaderboard ($M = 3.86$) were positive but more variable, suggesting mixed responses to social comparison. Standard deviations can be found in Table 2.

4.3.3 Qualitative Feedback. Thematic analysis revealed three primary themes: increased awareness, behavioral change, and the value of immediate feedback.

Increased Awareness. Participants described becoming more mindful of portion sizes and food selection, noting that weighing waste prompted reflection on what they intended to eat. Several adopted strategies such as taking smaller initial portions and returning for more if needed.

Behavioral Change. Many participants reported changes in serving behavior, including taking smaller portions and trying to finish their plates. One participant described the system as "a good reminder to stop and think about what I

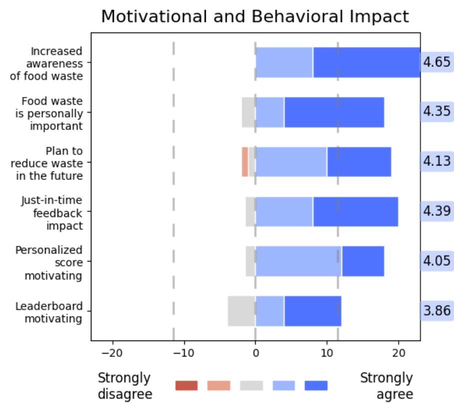

Fig. 2. Likert-scale responses for motivational and behavioral-impact items. Higher mean values indicate stronger agreement with statements about awareness, intention, and the impact of just-in-time feedback.

would actually eat." However, some noted that food quality sometimes outweighed waste considerations, indicating limits to awareness-driven change.

Value of Immediate Feedback. Participants consistently valued immediate scoring. Many reported increased motivation when receiving a score and disappointment when feedback was absent. Some also highlighted the social visibility of the system, noting that it sparked conversation in the dining hall.

Suggestions for Improvement. Suggestions focused on reducing friction and increasing integration into dining workflows. Participants suggested greater automation, closer placement to trash bins, and more supportive framing to reduce embarrassment when disposing of high-waste plates.

5 Discussion

This study demonstrates that the FWS was usable and effective at increasing awareness of personal food waste in a real-world dining context. Participants rated the system as "Excellent" in usability and reported strong perceived impacts from just-in-time feedback, suggesting that the system's simple, just-in-time design successfully integrated into existing dining routines. High learnability and confidence scores indicate minimal instruction was required.

Quantitative and qualitative findings show increased awareness as the FWS' strongest impact. Participants consistently reported becoming more mindful of portion sizes and food selection, often adopting strategies such as taking smaller initial portions. This aligns with prior work suggesting that immediate, contextual feedback can support reflection and behavior change without requiring sustained attention or prior motivation.

While both the personalized score and public leaderboard were rated positively, responses to the leaderboard were more mixed. Qualitative themes suggest that social comparison can be motivating for some users while uncomfortable for others, particularly when waste is visible to peers. This highlights an important division that some features encouraging competition around dining behaviors may increase engagement, but risk embarrassment or disengagement for some users. Our findings suggest that social feedback should be carefully framed or optional in contexts involving moralized behaviors such as waste.

Importantly, increased awareness did not always translate into reduced waste. One participant noted that food quality sometimes outweighed waste considerations, indicating that structural factors beyond individual behavior (such as menu design and food preparation) also shape outcomes. This reinforces the idea that behavioral feedback systems like the FWS are best understood as complementary interventions rather than standalone solutions.

6 Limitations and Future Work

This study has several limitations. First, the sample size was small and drawn from a single AYCE dining hall at one university, limiting generalizability to other dining contexts and populations. Second, the two-week study duration constrained our ability to observe longer-term behavior change, habit formation, or novelty effects. Although participants reported increased awareness and perceived behavioral change, we could not determine whether food waste, measured by dish weight, decreased over time. Third, several outcomes relied on self-reported Likert-scale responses and qualitative reflections, which capture perceived awareness and motivation but may not fully reflect actual behavior. Fourth, participant behavior may have been influenced by observation effects, particularly early in deployment. Finally, although the study used a within-subjects design, participants were randomly assigned to feedback conditions on each login. A structured crossover design, in which participants experience one condition for a fixed period before switching, could allow clearer attribution of effects to specific system features.

Future work should explore longer-term deployments to examine sustained behavior change, habit formation, and novelty effects. Extended studies would also enable direct analysis of food waste trends over time, providing stronger quantitative evidence of impact. Deeper integration into dining workflows (e.g., placing scales beneath trash receptacles) could reduce friction and increase participation. Future studies should also consider structured crossover designs and deployments across multiple dining contexts to improve generalizability and better understand how social norms and institutional factors shape responses to personalized food waste feedback.

7 Conclusion

This paper asked a question with important implications for campus sustainability: when food waste happens at the individual level, can feedback that is immediate and personal change how people think and behave? Our results suggest that it can. In a two-week deployment of the FWS at an AYCE dining hall, participants rated the system as highly usable and reported increased awareness of what they took, ate, and discarded.

At the same time, the study highlights tradeoffs between feedback mechanisms. Personalized scoring and immediate messages were broadly motivating, while the leaderboard produced more mixed reactions, suggesting that social comparison can energize some users but feel uncomfortable for others in moralized contexts like waste. Several participants also pointed to structural constraints, such as food quality and dining hall offerings, that influence waste regardless of awareness. Together, these findings position FWS as a practical intervention that complements broader institutional sustainability efforts rather than replacing them.

Ultimately, FWS demonstrates how translating waste into an interpretable score can motivate better behavior. By connecting measurement to immediate reflection, individualized eco-feedback systems like FWS can help campuses move beyond generic reminders and toward interventions that meet people where waste actually happens, one plate at a time.

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A Ethical Implications

We conducted this research in a shared dining environment in which social norms, peer visibility, and institutional power structures shape everyday behavior. All authors are members of the same university community in which the study took place, and familiar with the dining environment under study. This positionality influenced both the design and interpretation of the system: we were attuned to informal dining hall dynamics, social pressure, and what would feel motivating versus judgmental to students. At the same time, this proximity may bias interpretation toward norms common in residential colleges at selective U.S. universities. To mitigate this, we emphasized participant-reported experiences, anonymized public-facing features, and reflexive interpretation of qualitative feedback, especially when participants expressed discomfort or resistance.

From a broader impact perspective, personalized feedback systems like the FWS carry ethical risks alongside their benefits. While intended to promote reflection and sustainability, such systems could be misused to shame individuals or encourage restrictive eating behaviors—especially if deployed without consent or transparency. Public leaderboards, in particular, risk amplifying social pressure around moralized behaviors such as waste. In this study, participation was voluntary, participants self-selected any personally identifying information on the leaderboard, and we restricted all individual-specific data to the researchers before deleting it after analysis. Future deployments should maintain these safeguards, provide opt-out mechanisms, and frame feedback as supportive. Designers should also remain cautious about extending such systems into contexts where power imbalances (e.g., employment or grading) could transform feedback into coercion.

Accessibility was not a primary focus of this initial prototype and represents an important area for future work. The system assumes users can stand, read a screen, interact with a keyboard, and physically place dishes on a scale. That said, screens were kept bright, buttons were large, and the custom web interface was designed with basic accessibility considerations in mind. Still, this design may exclude users with mobility impairments, visual impairments, or cognitive differences. Future iterations should explore multimodal input and output (e.g., screen reader compatibility and touchless interaction), alternative placement of sensing hardware, and broader testing with users of varied abilities. Ensuring that sustainability interventions are inclusive is critical to avoiding systems that disproportionately burden or exclude certain populations while pursuing the goal of reducing food waste.

B The FWS Equation

$$\Delta = \max(0, w - B)$$
$$\text{FWS} = 100 \cdot e^{-\Delta/\lambda}$$

where w is the discarded food weight in grams, B is a baseline goal weight representing typical waste without feedback, Δ is excess waste above an average baseline amount (clamped at 0), and λ is a decay constant controlling how quickly the score decreases. If λ is set such that $\lambda = h/\ln 2$, then h represents a half-life in grams: each additional h grams above the baseline halves the remaining score. Baseline and decay parameters were tuned per dish type prior to deployment, and final scores were clamped to the range $[0, 100]$.

C Post-Study Questionnaire

C.1 System Usability Scale (SUS)

Please rate your agreement with each statement on a scale of 1 to 5, where 1 = *Strongly Disagree* and 5 = *Strongly Agree*.

(1) I think that I would like to use this system frequently.
(2) I found the system unnecessarily complex.
(3) I thought the system was easy to use.
(4) I think that I would need the support of a technical person to be able to use this system.
(5) I found the various functions in this system were well integrated.
(6) I thought there was too much inconsistency in this system.
(7) I would imagine that most people would learn to use this system very quickly.

(8) I found the system very cumbersome to use.
(9) I felt very confident using the system.
(10) I needed to learn a lot of things before I could get going with this system.

C.2 Awareness and Behavioral Impact

Please rate your agreement on a scale of 1 to 5, where 1 = *Strongly Disagree* and 5 = *Strongly Agree*.

(1) Using the Food Waste Score (FWS) system increased my awareness of my personal food waste.
(2) Reducing food waste is important to me personally.
(3) I plan to take smaller portions or reduce food waste in the future as a result of using FWS.
(4) The just-in-time feedback (seeing your score immediately after your meal) impacted my thoughts on food waste.

C.3 Motivation and Gamification

Please rate the motivational impact of the following features on a scale of 1 to 5, where 1 = *Not at all motivating* and 5 = *Extremely motivating*.

(1) The personalized 0–100 score for your own meal.
(2) The public dining hall leaderboard (if you used it).

C.4 Free-Response Feedback

Please answer the following questions in your own words.

(1) What did you like most or least about the Food Waste Score system?
(2) Do you have any suggestions for improvement?

D Figures and Tables

Fig. 3. The FWS set up in a university dining hall.

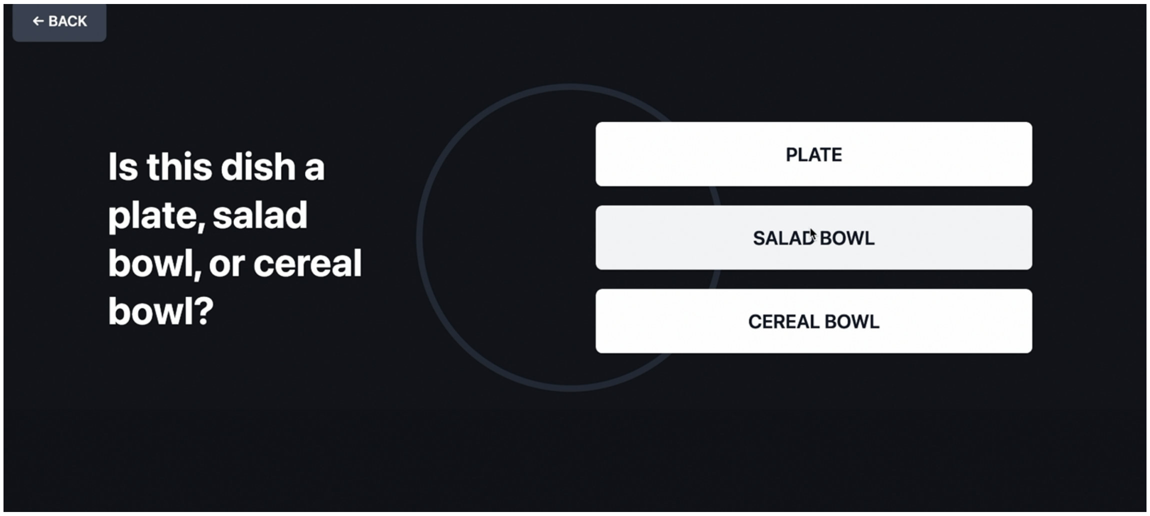

Fig. 4. Selecting dish type on the FWS.

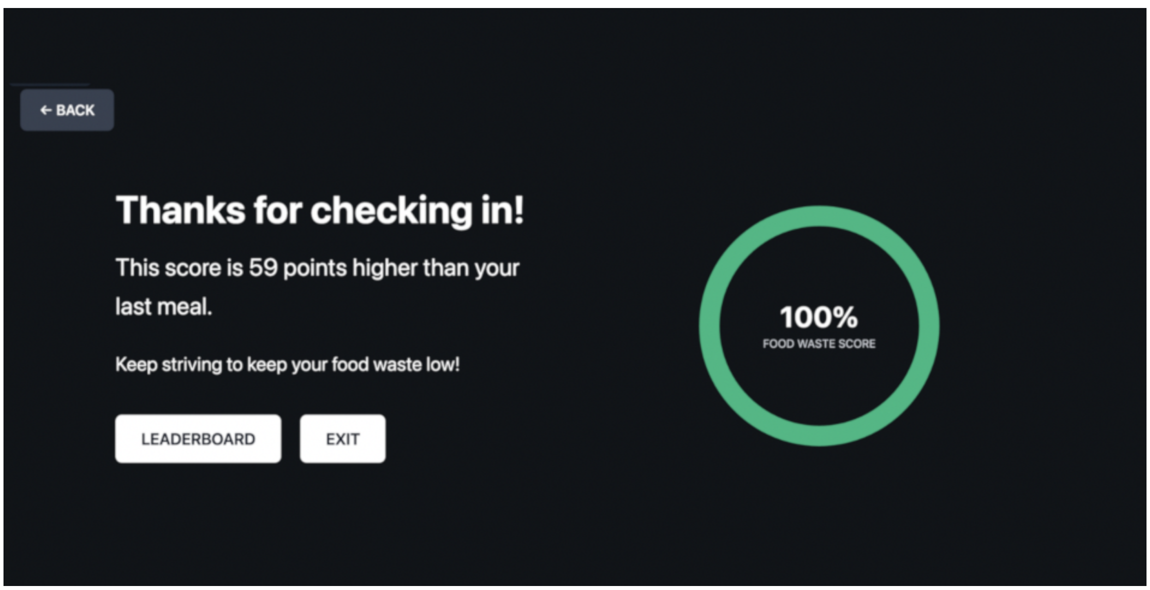

Fig. 5. The FWS displays a score to a user.

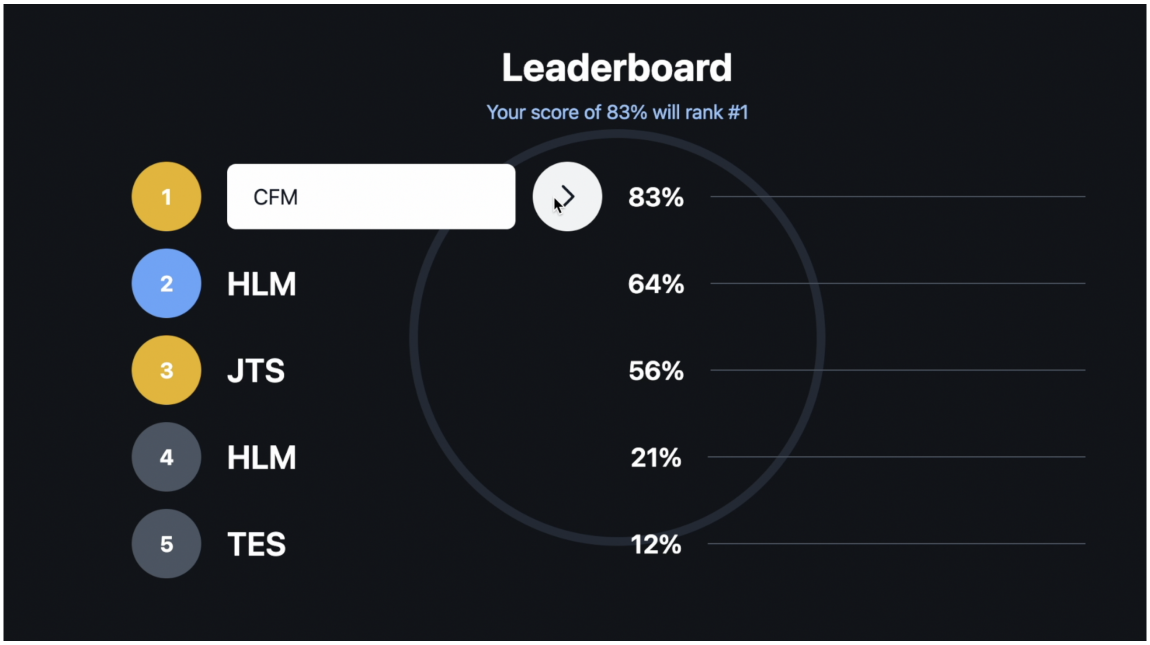

Fig. 6. Entering initials into the FWS leaderboard.

Table 1. SUS-adjusted item means (0–4), N = 22. Higher values indicate more positive usability.

#	SUS Item	*M*	*SD*
1	I think that I would like to use this system frequently.	2.86	0.99
2	I found the system unnecessarily complex.	3.36	0.90
3	I thought the system was easy to use.	3.45	0.74
4	I think that I would need the support of a technical person to be able to use this system.	3.45	0.91
5	I found the various functions in this system were well integrated.	3.50	0.51
6	I thought there was too much inconsistency in this system.	3.32	0.95
7	I would imagine that most people would learn to use this system very quickly.	3.73	0.46
8	I found the system very cumbersome to use.	3.36	1.09
9	I felt very confident using the system.	3.59	0.50
10	I needed to learn a lot of things before I could get going with this system.	3.41	1.05

Table 2. Mean ratings for motivation and behavioral-impact items (1 = strongly disagree, 5 = strongly agree).

#	Item	*M*	*SD*
1	Increased awareness of personal food waste	4.65	0.49
2	Personal importance of reducing food waste	4.35	0.93
3	Intention to reduce food waste in the future	4.13	0.92
4	Impact of just-in-time feedback	4.39	0.72
5	Usefulness of the personalized score	4.05	0.79
6	Usefulness of the public leaderboard	3.86	1.11