Summary

This paper investigates how a digital system can promote sustainable food choices by supporting both canteen customers and the kitchen manager in understanding and reducing food-related CO2e emissions within a municipal canteen in Aalborg, Denmark. The study builds upon a preliminary project carried out by the authors during the autumn of 2024, which resulted in a system capable of calculating food-related CO2e emissions from procurement invoices. While this initial system successfully generated emissions data, it did not address how this data could be applied meaningfully within the canteen environment to influence behaviour or support sustainable practices. This project aims to fill that gap by exploring how a digital system can serve as a medium for eco-feedback and behavioural engagement in a canteen context.

To guide the development process, we employed a user-centered design approach with the kitchen manager as the primary stakeholder. The design process began with a semi-structured interview that provided insight into the daily routines and motivations of the kitchen manager. Based on this interview, we identified a set of core requirements for the system, which informed the design of two distinct interfaces: a customer-facing dashboard and a kitchen manager dashboard. Drawing on prior eco-feedback research, the customer dashboard used both quantitative and figurative visualizations, goal-setting metaphors, and learning mechanisms to foster awareness and engagement while the kitchen manager dashboard provided analytical tools for analysing the canteen emission.

The first iteration of the design process concluded with the development of a low-fidelity paper prototype which was evaluated in a second semi-structured interview with the kitchen manager to validate the concept and gather feedback for refinement. The positive reception and feedback from this session informed the second design iteration, which led to the development of a fully functioning web-based system. The kitchen manager dashboard offered tools to visualize historical emission trends and compare ingredients based on both climate impact and nutritional value. The customer dashboard presented the emissions of daily menus using car trip metaphors, pie charts, and progress bars contextualized against municipal reduction goals. Customers could also submit feedback on meals via a mobile interface.

To evaluate the system, it was deployed in the canteen over a five-week period. During the final week, data was collected through a customer questionnaire, nine semi-structured customer interviews, and a concluding interview with the kitchen manager. Questionnaire responses showed high levels of user interest in system acceptance. Customers expressed curiosity about ingredient emissions, and several asked for recipes, indicating a degree of learning and engagement. However, usability issues were noted particularly around the feedback interface, which relied on QR codes as many users did not have their phones available during lunch, resulting in a relatively low volume of customer feedback submissions.

The interview with the kitchen manager provided deeper insights into the system’s organizational impact. While he was already sustainably aware, he appreciated the system’s ability to validate and visualize their efforts. Notably, visualizations showing a more even distribution of emissions over time prompted changes in the design of the salad bar and helped reinforce the canteen’s evolving sustainability practices. Furthermore, the system appeared to open new avenues for communication between staff and customers, as more individuals approached the kitchen to discuss recipes or ask about ingredients. These findings suggest that eco-feedback systems can strengthen connections between operational decisions and customer perceptions.

The discussion highlights several broader implications. While the system did not provide a direct mechanism for reducing emissions, it succeeded in making emissions data visible, accessible, and actionable. It sparked dialogue, reinforced existing sustainability goals, and provided a platform for continuous learning and reflection. However, the system also introduced unintended effects. For example, by emphasizing whether the canteen was staying "under target," some customers interpreted this as permission to reintroduce higher-emission foods, such as meat. This illustrates the complexity of framing and goal-setting in eco-feedback systems and suggests that success metrics must be communicated carefully.

The study concludes that while eco-feedback systems alone may not dictate specific pathways to emission reduction, they can play a valuable role in supporting sustainability in organizational contexts. Their effectiveness lies not only in their data or visuals but in how they are embedded into everyday routines, physical spaces, and social structures. Future research should continue to explore how digital systems can act as catalysts for sustainable behaviour by aligning with user motivations, organizational goals, and the nuanced dynamics of collective action.

International Journal of Computer Applications (0975 - 8887)
Volume 1 - No.1, June 2025

Designing an Eco-Feedback System to Promote Sustainable Practices in a Canteen

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ABSTRACT

In this study, we explore how emission data be used to reduce CO2e emission in a municipal canteen. By following a user-centered design process, we conducted interviews with the kitchen manager, developed a paper prototype, and implemented a working system that was deployed in the canteen over a five-week period. The system provided customers with contextualized visualizations of menu emissions and enabled them to submit feedback for the kitchen manager on today's menu, while offering the kitchen manager analytical tools to monitor kitchen emissions. Evaluation through questionnaires and interviews showed positive reception from both the kitchen manager and customers, with indications of increased environmental awareness and behaviour change. We reflect on these experiences and propose directions for future refinement of eco-feedback systems in a canteen context and conclude that eco-feedback systems can play a meaningful role in fostering sustainable practices in canteen settings, provided they are carefully integrated into existing routines and organizational culture.

General Terms

CO2 equivalent (CO2e), Human Computer Interaction (HCI), Sustainable Human Computer Interaction (sHCI), Consequence-based Life Cycle Assessment (CLCA), Low Fidelity (Lo-Fi).

Keywords

Sustainability, eco-feedback, canteen, food products, emission.

1. INTRODUCTION

As the effects of the world's CO2e emissions have become apparent through climate changes, the need for behavioural and structural change has grown during the last decades[26]. Rising temperatures and sea levels are examples of such changes, which pose a danger to millions of people worldwide, as well as to marine and terrestrial ecosystems[13]. Despite the need to slow down CO2e emissions, the world population is growing, creating more demand, which causes an increase in production, consumption, and emissions[31]. Due to this growing demand this, there is a need to find sustainable alternatives and practices across all social structures[26]. The sustainable research conducted in the field of HCI has typically focused on sustainable consumption from an individual perspective, as consumers are responsible for more than 60% of global CO2e emissions[18]. Although behavioural change can have significant impact, recent critiques highlight the need to move beyond the individual to address sustainability at systemic and organizational levels.

In this paper, we broaden the focus to an organizational level, specifically a canteen in the municipality of Aalborg, Denmark. The paper is a continuation of the work produced during a preliminary study conducted in the autumn of 2024[20]. In the preliminary study, we discovered that the municipality and the kitchen manager were interested in mapping out their CO2e emissions, as they had set a goal to reduce their food-related emissions by 25% by 2028, starting from 2018[23]. In the study, we focused on the emissions related to the procurement and consumption within the canteen in the municipality building. The result of this study was a system which allowed the sustainability controller of the municipality to upload invoices and receive formatted emission data of food items purchased within the municipality. Although the paper yielded a working classification system for food items, we did not further investigate how this data could be useful within a canteen context.

Motivated by finding solutions for implementing sustainable food practices, climate change, and the shortcomings of the preliminary study, we present the research question:

> *How can a digital system promote sustainable food choices by supporting both canteen customers and the kitchen manager in understanding and reducing food-related CO2e emissions?*

To answer the research question, this study follows a user-centered design approach, with the kitchen manager as the central user. The applied design approach is an iterative process consisting of four distinct phases, as depicted in Figure 1.

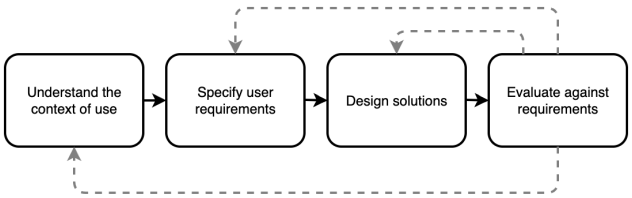

Fig. 1. User-centered design model

Through this method, we design a system based on experiences from existing sHCI research and the research conducted during this study. The aim of this paper is to follow the user-centered design approach to design and evaluate the impact of a proposed solution.

2. RELATED WORKS

This section presents the first step of our user-centered design approach; understand the context of use, as seen on Figure 1. This section positions our work within the field of sHCI and presents existing design experiences from eco-feedback systems which guides the design process presented in subsection 3.3.

2.1 Evolution of Eco-feedback Systems in sHCI

Eco-feedback systems inform the user of their resource consumption with the intention of reducing environmental impact[15]. Early eco-feedback system research has largely focused on individuals and households, as consumers are large contributors to resource consumption[19]. These systems has primarily used persuasion as a technique towards long-term behaviour change[6, 10]. Different designs and representations of data have been used across a range of different eco-feedback systems in order to persuade [16, 14, 27, 17]. These designs commonly assume the user to be a rational agent choosing optimal behaviour towards sustainability when presented with their consumption data[29, 30].

This dominant approach to eco-feedback systems, where designers assume the user to be a rational agent, has been critiqued for narrowing the view of how sHCI should contribute to sustainability[7]. Research shows that assuming people to be rational agents does not reflect in reality, as actions are influenced by behavioural and social factors[21]. This became the start of a shift in focus within the sHCI community with recent research considering a more holistic view, where user motivations and routines are important factors in fostering sustainable behaviour[22]. Another proposal has been to shift the focus from the individual level to an ecological level, focusing on the complex structures and interrelationships between people and their environment[25]. The strength in this approach being that a design considers multiple actors and identifies otherwise unpredictable consequences of a possible solution.

Despite reconsidering how HCI should contribute to sustainability, much research is still needed to design systems that will change behaviour and practices. The complex nature of different domains and people's interactions makes it difficult to design a one-size-fits-all solution. As stated in [22] "the community is still struggling to converge on a shared understanding of sustainability and HCI's role in addressing it". This research must reconsider how to understand the problem domain sufficiently, as well as how to design solutions that create engagement and foster learning.

2.2 Experiences From Eco-Feedback Research

Prior research has explored different design approaches that highlights both positive and negative design aspects in various contexts. Positive design aspects should be understood as design choices which foster learning, engagement or sustainable behaviour. Negative design aspects should be understood as design choices that can deter users from engaging with eco-feedback systems and in other ways promote a negative user experience.

A factor in creating a positive user experience is customizability, which acknowledges that users have different mental and emotional prerequisites[28, 21]. Systems that provide options for personalization, enhance user engagement by making the feedback more relevant to individual preferences. Balancing quantitative elements such as numerical data and figurative elements such as visual metaphors also has an impact on user engagement in eco-feedback design. While quantitative clarity supports understanding, emotional engagement through relatable visual metaphors enhances motivation, especially among non-technical users[28].

While displaying direct measurement units provide insight into e.g. CO2e emissions, direct measurement units have to be contextualized by meaningful or relatable visualizations to raise consumption awareness. Studies have shown that solely displaying direct measurement units (e.g. kWh, litres, CO2 emissions) without contextualization is ineffective in changing user behaviour and raising consumption awareness. Users often struggle to interpret raw scientific measurements, and without meaningful comparisons or relatable visualizations, the impact of the feedback is weakened [2, 21, 30].

Fostering positive emotions such as pride and satisfaction can also encourage sustainable behaviour. In a study where the authors examined user's emotional reactions after performing sustainable actions, a feeling of pride rose from users being proud of themselves by remembering to take the effort of behaving sustainably and a sense of satisfaction from succeeding in contributing to conserving resources. Additionally, the study indicated that imposing negative emotions, such as guilt or embarrassment, may lead to immediate behavior change but can discourage users in the long run[3].

Learning mechanisms have been shown to increase engagement as well. In a study where users received detailed product information of factors that influence their ecological impact by scanning barcodes of food-related products, researchers found that users were motivated to use the implemented system in cases where the users were curious about the ecological footprint of known products[11].

In a study where an eco-feedback system was designed based on 19 design requirements and deployed on a university campus, the authors aimed to ask users to propose suggestions of change to the requirements after interacting with the system. Here, the authors found that users were less focused on proposing solutions for the requirements related to the CO2 concentration, especially for the ones deriving from transportation. The authors suggested that the system did not give a real time feedback about the consequence of the everyday actions, which indicated that timely feedback, particularly real-time feedback, has a positive impact on sustainable behaviour by supporting sustainable actions as they occur[12]. Receiving untimely eco-feedback - feedback that

is received too late for it to be actionable, greatly reduces its effectiveness. Immediate and contextual feedback is essential for reinforcing sustainable behaviours[12].

In relation to data- and time-granularity, users prefer the ability to explore different temporal ranges rather than being restricted to predefined views. Allowing self-comparison over time increases motivation, as users strive to improve their past performance[21]. When displaying data, effective information visualization strategies enhance users' ability to comprehend data. A structured design approach with "overview first, zoom and filter, details on demand" prevents information overload and maintains usability[9]. Additionally, what-if simulations that enable users to model the effects of different choices enhance their understanding and decision-making processes[32].

Studies have also found that persuasion techniques positively affect behaviour change. Incorporating persuasive strategies, such as behavioural nudges and goal-setting, has been effective in encouraging sustainable behaviours[24]. Even though goal-setting has been shown to offer advantages when trying to change users' behaviours, setting predefined sustainability goals can be problematic, as preferences for goal-setting methods vary widely. Users tend to favour self-imposed goals over externally set ones, indicating a need for customizable goal-setting mechanisms. Additionally, personally identifiable comparisons, where individual performance is directly compared with others, can lead to resistance or disengagement due to the feeling of shame and perception of being judged[21, 28].

Goal-setting based on social norms, could however be particularly useful, when sustainable group behaviours are identified and encouraged, as collective thinking and the feeling of belonging to a group may encourage users to adopt more sustainable behaviours[1, 33]. Visualizing the distribution of sustainable behaviour within a reference group (e.g. through leaderboards or point systems) can activate social norms and encourage individuals to change behaviour. Berger & Schrader suggest in their study on how to foster sustainable nutrition behaviour that such reference groups can transform individuals from "intenders" to "actors" by leveraging social influence, as seeing what others do and what others approve of can guide behaviour[5]. Additionally, social norm-based feedback (indicating what others approve of) also had an impact in the authors' study on sustainable food purchasing decisions. Combining social norm-based feedback with descriptive feedback (indicating what others are doing) showed positive effects, suggesting that integrating social norms into gamified systems can influence consumer behaviour toward sustainability[4].

Research has shown that non-intrusive dashboards, for example screens that does not stand in the way, while initially might seem appealing, can reduce long-term engagement. If users are not actively reminded or motivated to interact with the system, the impact diminishes over time[33]. In organizational contexts, eco-feedback should be embedded within existing workflows to avoid cognitive overload and improve usability. Eco-feedback should not be the same for users working on the strategic and operational level. Here, the strategic level should be understood as managers and decision-makers, focusing on long-term planning and strategies, and the operational level should be understood as staff that carry out the tasks in practice that is planned at the strategic level. Feedback for staff at the operational level should be simple and action-oriented and feedback for decision-makers at the strategic level should include analytical tools[8, 9]. Eco-feedback systems that operate as standalone applications often fail in organizational contexts due to complex IT infrastructures, as detached eco-feedback tools can be disruptive in the day-to-day work. Therefore, a seamless integration into existing platforms is preferred [8].

3. METHODS

This chapter consists of subsections that present a new phase of the design process, starting with an interview with the kitchen manager in subsection 3.1 which expands on the contextual understanding obtained from researching related works in section 2, followed by a requirement specification in subsection 3.2. Based on the requirements, subsection 3.3 describes a prototype design that is evaluated through a new interview in subsection 3.4. Together, these sections conclude the first iteration of the user-centered design approach as seen on Figure 1.

3.1 Interview 1

To understand the motivation of the kitchen manager we conducted a semi-structured interview. The goal of the interview was to understand the daily routines within the kitchen and the decision-making process regarding the menu planning. We also sought to gain information about the kitchen managers prerequisites for engaging in the project and his attitude towards sustainability. We start off the interview by asking how the kitchen manager spends his time on a typical day.

> *"There are some office tasks that does take a lot of time but we have to do them. I would say cooking is 80% of it and 20% office approximately."*

Although these administrative tasks are mainly his domain he often has help from another experienced chef within the kitchen which we will refer to as the sous-chef. The kitchen manager elaborates and tells us that generally, all of the kitchen staff is culinary trained chefs and they all participate in the cooking of meals as well as cleaning and other tasks. We found that what primarily separated the kitchen manager from the other staff was his administrative responsibilities which was including but not limited to performing ecology reports, planning the menu and purchasing ingredients.

When asked about the decision-making process of what gets put on the menu he told us that they have complete creative control over the menu and are also responsible for purchasing the ingredients needed to create the menus. Despite complete control of what to put on the menu, the municipality impose certain restrictions, such as a budget. However, they do not consider this a restriction on the menu as they usually adhere to the budget. One of the kitchen managers administrative tasks is to file ecology reports. The current restriction imposed by the municipality is that 60% of the products used by the kitchen must be organic. When asked about this restriction he told us that it was a big challenge at first. However, their suppliers have made it simpler to choose and purchase organic products through their web-portal although these products are typically more expensive. Our interest was sparked when he mentioned the web-portal, as we are interested in gaining insight into what kind of IT systems that are used in the kitchen and how the kitchen manager accesses them:

> *"We have eSmiley for ecological reporting and Hørkram for ordering food. And then we have a webshop where we can buy from other suppliers. [. . .]*

> *They (the web apps) are always there when I turn on the computer. Then a start screen appears and I just press an app"*

The kitchen manager shows us the start screen. We can see that it is a web-portal hosted on the municipality's intranet. It appears as if more links to web applications can be added for easy access. When we asked about dietary requirements of the food he procures, he told us that the municipality had an increasing focus on lowering CO2e emissions and complying with animal welfare. This had prompted the municipality to ban the sale of beef, lamb and specifically "turbo chicken" in the kitchens.

> *"We decide the menus and then procure the food. It is 100% us that decide what gets on the menu except we can't serve beef, lamb and "turbo-chickens" where they are fed too fast."*

Additionally the municipality has imposed that the canteen must reserve two days for vegetarian menus to reduce emissions. However, they only have one as Fridays menu consists of the weeks leftovers. When asked about these restrictions, he said that he was disappointed at first as it is a professional interest for him to cook with these ingredients. However, upon learning about the environmental impact of different ingredients and sustainable cooking through courses supplied by the municipality, the restrictions felt less imposed. Despite an existing sustainability awareness, the kitchen manager is still interested in reducing the canteen's emission by creating sustainable meals. However, this is becoming increasingly difficult and he needs further insight into emission data to support reductions:

> *"We've put in a lot of effort in moving away from (unsustainable) food products and it's getting harder to find out where to cut emissions, it would be nice to be able to see the impact of the effort"*

In the last part of the interview, the questions became more personal in order to determine his interest in sustainability. From these questions we found that that he has a positive attitude towards sustainability and that he has even implemented a vegetarian day at home. We also found that he is greatly motivated by receiving positive feedback from the customers, especially on new menus with sustainable ingredients. Customer feedback inspires him to further research new recipes and ingredients. He further explained that he takes great pride in his work and that he likes to share his recipes and knowledge of cooking sustainably with customers:

> *"It's quite a task in the beginning, but the more you do it, the better you get at finding new recipes. Today, for example, we serve a beetroot cake. [. . .] when people give positive feedback, we really enjoy it and want to find even more recipes"*

When we further inquired about his interest in the kitchen's emission data, we found that he was interested in communicating the results of their efforts to reduce their climate footprint to the customers, due to the staff's increased sustainability awareness. He even specifically mentioned a poster with the yearly emissions as a possible solution.

> *"When we spend so much time and make an effort (to reduce emissions), it would be nice if we could see the effects of it, also to show the customers"*

3.2 Requirements

To derive the system requirements, we analyzed the motivations, needs, and constraints identified through our semi-structured interview with the kitchen manager laid out in subsection 3.1. Each requirement below is grounded in specific insights from the interview. To support both the kitchen manager and canteen customers, the system must fulfil the following requirements:

(1) The kitchen manager must have access to ingredient emission data.
(2) The kitchen manager must have access to menu feedback.
(3) The customers must be able to provide menu feedback.
(4) The customers must have access to canteen emission data.
(5) The system must be web-based and able to run in a browser.

3.2.1 Requirement 1. The kitchen manager is highly motivated to reduce the canteen's emissions. However, after removing high-impact ingredients such as beef and lamb, it is becoming harder to identify areas for further reductions. Continued improvements in sustainability require access to detailed data about the emissions of different ingredients. This information is important for data-driven decision-making when designing new menus.

3.2.2 Requirement 2. The kitchen manager is strongly motivated by customer feedback, especially when it affirms the use of sustainable ingredients. This feedback reinforces his interest in sustainable menu planning and encourages experimentation. To sustain motivation and support creativity, the kitchen manager should be able to easily view and reflect on customer responses to dishes.

3.2.3 Requirement 3. Positive interaction between customers and the kitchen manager is a key motivator. Customers often ask for recipes and comment on meals, indicating a willingness to engage. The system should support two-way interaction, allowing customers to give feedback on the menus to support communication and improvement.

3.2.4 Requirement 4. The kitchen manager expressed a desire to communicate their sustainable efforts to customers. He mentioned visual displays, such as posters showing yearly emissions, to make the impact visible. Transparency about emissions can increase customer awareness and reinforce the kitchen's role as a sustainability role model, especially for younger generations.

3.2.5 Requirement 5. The kitchen manager uses web apps through a web portal on his office computer. He showed a preference for tools that are already integrated into his workflow. To ensure adoption and avoid disrupting routines, the system must run in a web browser and be compatible with the existing kitchen IT setup.

3.3 Paper Prototype Design

This section describes the process of designing lo-fi paper-prototypes. The designs presented in this section includes two separate dashboards to fulfil the requirements of subsection 3.2 and is guided by the existing design experiences presented in subsection 2.2.

3.3.1 Requirement 1: The kitchen manager must have access to ingredient emission data. Related works suggest that eco-feedback on a strategic level, i.e. where decision-makers, as managers, conduct planning and take stategic decisions, should include analytical tools[8]. Based on this, we suggest an *ingredient explorer component* (seen on Figure 2) where the kitchen manager can select two

ingredients and compare their nutrition and emission. This design utilizes a "what-if" scenario that should enable the kitchen manager to model the effect of different ingredient choices, with the purpose of easing the decision-making process[32].

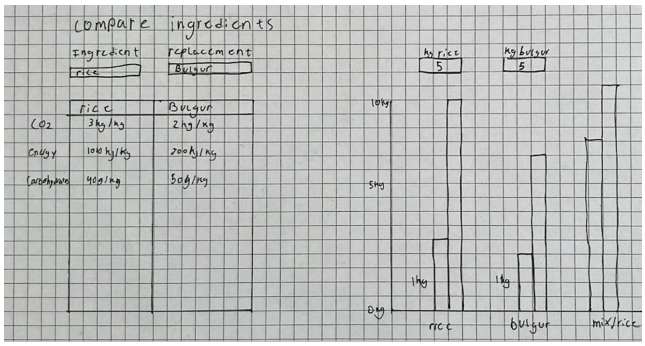

Fig. 2. Manager dashboard: ingredient explorer

To provide further access to ingredient emission data for the kitchen manager, we also propose a quantitative data visualization of the kitchen's historical emission data using a bar chart and a pie chart. This can be seen in the *emission analysis component* on Figure 3. Related works suggest that it should be easy to explore different temporal ranges[21], so the component has predefined shortcuts for doing so. The default view is to display all available data, then, the shortcuts can be used to zoom in on different periods, and lastly, if wanted, more detail of a given period should be accessible[9]. An illustration of the shortcuts can be seen in the upper-part of the *emission analysis component* on Figure 3 ("Denne måned", "Sidste måned", "Q1", . . . , "Alt") and an illustration of how to get details on demand is visualized as a click on a "pie slice" of the pie chart in the right side on the illustration.

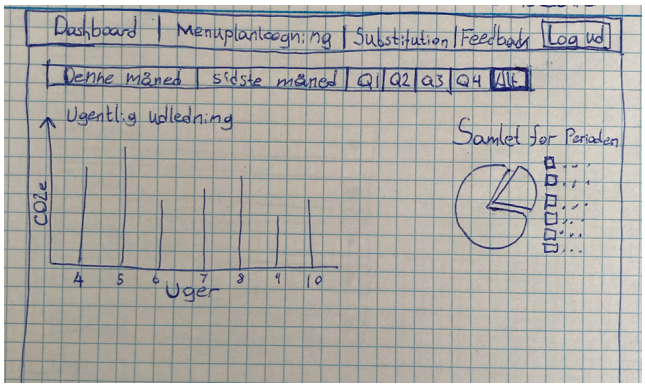

Fig. 3. Manager dashboard: emission analysis

3.3.2 Requirement 2: The kitchen manager must have access to customer feedback. The kitchen manager can review customer feedback as shown in the *feedback review component* on Figure 4. Here, the menus for each week is listed along with the rating and comments for each menu. Additionally, the menus can be sorted after best rating, as seen on the right side of Figure 4.

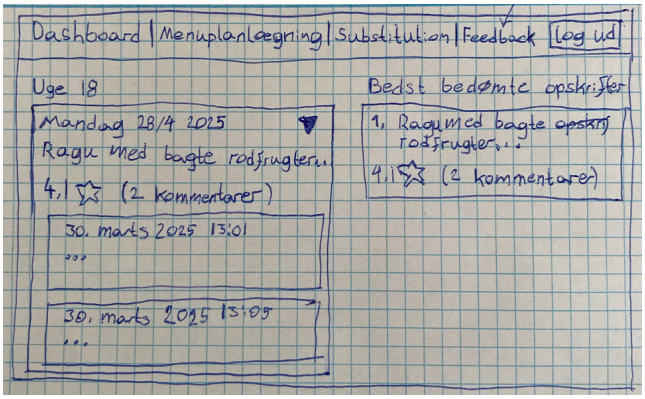

Fig. 4. Manager dashboard: feedback review

3.3.3 Requirement 3: Customers must have access to canteen emission data. When visualizing emission data, it must be acknowledged that users have different mental prerequisites for understanding the data. Users with technical backgrounds tend to favour quantitative data visualizations, as numerical elements, and users with non-technical backgrounds tend to favour figurative data visualizations, as visual metaphors[28]. Canteen customers may have varying backgrounds, so a mix of quantitative and figurative data visualizations is preferred. Based on this, we suggest a figurative data visualization of the emission of today's menu, illustrated as the distance of a car trip in kilometres with a corresponding emission. Additionally, the figurative visualization includes an alternative route, that displays the consequence of substituting one or more ingredients in today's menu. This plays to the strength of using a "what-if" scenario to model the consequence of an alternative choice, with the purpose of easing the customer's understanding of the environmental impact of using different ingredient[32]. This can be seen to the left on Figure 5). On the right side, we see a quantitative data visualization of the emission of today's menu, depicted as a pie chart with the menu's emission distributed among the ingredients comprising it.

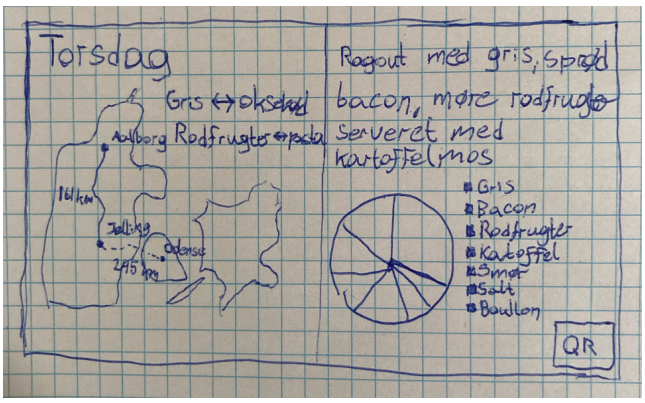

Fig. 5. Customer dashboard: canteen emission

An alternative component design for requirement 3 can be seen on Figure 6. The component includes quantitative- and figurative data visualizations and a "what-if" scenario (seen in the top-left section on Figure 6). The top-right section on the picture displays

a "CO2-prognosis" that quantitatively visualizes how much CO2 the canteen has actually emitted, compared to how much CO2 the canteen is allowed to emit according to the 25% reduction goal imposed by the municipality. This visualization makes use of goal-setting, as studies have shown that allowing for self-comparison over time, increases users' motivation to change behaviour[21].

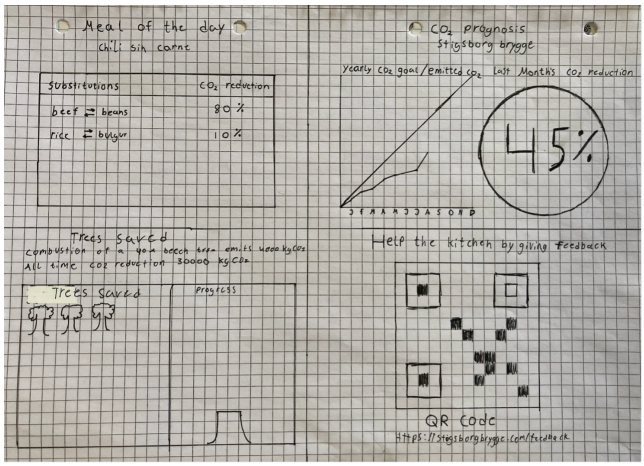

Fig. 6. Customer dashboard: CO2 prognosis

3.3.4 Requirement 4: Customers must be able to provide feedback on the menus. Canteen customers can provide feedback on the food served by scanning a QR as depicted on the bottom-right side of Figure 5. The interface consists of a list of the week's menus (seen on the left side on Figure 7). The feedback is provided by giving the menu a rating from 1 - 3 by selecting a smiley, then, an optional comment can be provided as well. Additionally, for each menu, the customer can see details of the emission of the ingredients comprising the menu. The idea is that the customer can get an overview of today's menu's emission by looking at the canteen dashboard and then, if wanted, more detail of the menus' emission can be seen in the feedback interface. This follows the principle of "overview first, then zoom and filter, details on demand" as described in [9]. The feedback consists of a rating (three smileys as an example) and an optional comment.

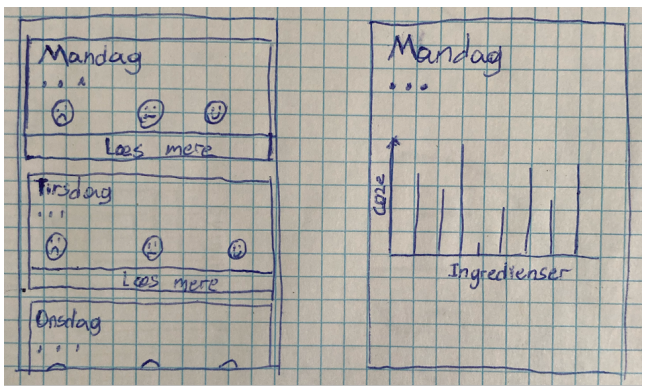

Fig. 7. Customer dashboard: feedback submission

3.4 Interview 2

To evaluate our prototype we presented the kitchen manager with the key goals we had identified from the first interview and the idea of a using customer feedback for designing new menus. From the discussion it seemed the goals aligned well with his vision and the system idea was welcomed as a great idea as it allowed him to communicate his efforts to the customers. We begin the interview by showing the kitchen manager the paper prototype for the customer dashboard (seen on Figure 5) and discuss whether we can use a screen in the canteen and whether we can get data on the ingredients for each day's menu. He tells us that both are possible and immediately shows interest in the map component on the left side on Figure 5.

> *"[. . .] then you can see, on Monday's, where we have a vegetarian day, then that must be the shortest route, right? I think it's a great idea, it's very cool"*

Considering that the kitchen manager understands the map component intuitively at first sight, indicates that the visual metaphor of using a car trip to illustrate the emission of a menu is a sensible visualization. We also discuss the pie chart on the right side of the component. The kitchen manager likes it and understands it and does not have anything to add. We conclude that we should include the map element and the pie chart with 6 "slices"; the top-5 emitting ingredients and the rest as a single slice called "other ingredients".

We also discussed the practical implications for displaying an alternative route on the map by providing alternative ingredients. We told him that the idea came from our first interview where he expressed a wish for conveying his knowledge about sustainable ingredients and inspire customers to eat more sustainably. He was very positive towards the idea and told us that this was something that people would be able to understand.

> *"This is something that people will understand. If you just write something (a number) on the screen nobody knows anything but if you show them this map i think it will make them stop and look."*

In continuation of our discussion about using alternative ingredients to display an alternative route on the map, we came to the agreement that we would decide on the ingredient substitutions.

Furthermore, we also presented him with an alternative version of the customer dashboard (seen on Figure 6) and discussed the CO2e-prognosis. He does not understand it at first sight and ask if the monthly view will change every day or if it will be static. We respond by saying that the idea is mainly to show that the kitchen emission is below the allowed threshold. We suggest a simpler design of a component that can still show that the canteen performs well; a "CO2e-progress bar" that displays a supportive message when the emission is below the threshold. The kitchen manager responds:

> *"That is a really good idea, it really is [. . .] I think it's (the progress bar) better. I really do, the thing with the text is a good idea"*

We conclude that we should design a simpler component and that a CO2-progress bar would be a good solution, as it still showcases that the canteen is performing well and is easier to interpret than the CO2-prognosis.

We present the kitchen manager with the idea, that customers can not only see emission data for today's menu but also provide feedback on it. We then show the design for the feedback submission component and the interface for reviewing it (seen on Figure 7 and Figure 4).

> *"That could be a good idea, sometimes they (the customers) come and share their thoughts on the menu, sometimes they don't, but they might think something [...] I gotta admit, that (the idea of customer feedback) looks really interesting"*

We discuss what kind of feedback would be interesting for him to receive. From this discussion we found that he would like to receive both a star-rating and an optional comment. When discussing multiple comments he expressed concern that they would be less inclined to use the system if they are presented with too much at a time.

> *"I think that in order to get people to give feedback they should not be presented with too much as they wont have the time to answer."*

Additionally he commented that people might be a bit dull when they are presented with a new initiative in which they actively have to participate. At this point we discussed the option of posting on the municipality message board to spread awareness about the project and the importance of the feedback. We settle on that the menu feedback should consist of a rating from 1-7, a toggle for indicating whether the customer would like to see if the menu could be more environmentally-friendly and an optional comment.

To communicate the canteens sustainability efforts to customers, we discussed a "show-off" component which we left blank for the interview to determine what he wanted to communicate. During this discussion it became apparent that he was restricted in his ideas as he did not know what would be technically possible.

> *"If we can get the data from 2018 and compare it to 2024 it would be nice to show how much has really happened. Because if we have to show it for each day that will be too much work (for you) right?"*

To ensure his ideas would be unrestricted we asked him not to consider the technical aspects yet and only consider what he wanted to show the customers.

In the last part of the interview we showed the analytical tools for supporting him to further learn how to reduce emissions (the *emission analysis component* seen on Figure 3 and the *ingredient explorer* seen on Figure 2). We discuss how we can visualize the emission data. Overall, the kitchen manager is satisfied with our proposal of using the combination of a bar chart and a pie chart for displaying the kitchen's historical emission data.

> *"I think that it is very nice to see the emission gathered for the month, then we would be able to send that out and show to the customers".*

Although it did not seem like he was particularly interested in using this component as a learning mechanism he did seem interested in receiving the data.

Throughout the interview we found that he was very positive towards the system and that we should start developing a working prototype. We also found that the customer dashboard should be centered around displaying daily emissions with a historical comparison while the manager dashboard would be using historical data. Upon this discovery we discussed the possibilities of acquiring the daily ingredients and quantities in order to calculate the daily emission. Through these questions we found that they usually do not cook with recipes so he would not be able to upload them, however we discussed adding a component to the system allowing him to manually type in the daily ingredients and quantities which he agreed to do throughout the experiment. In order to obtain the historical emission data we agreed to contact the municipality's sustainability controller with whom we had been in contact during the preliminary study [20].

4. SYSTEM DESIGN

This section presents the system design of the second prototype and commences the second iteration of the user-centered design approach as seen on Figure 1. The design process is guided by the evaluation of the paper-prototypes presented in interview 2, laid out in subsection 3.4.

4.1 Kitchen Manager Dashboard Design

The kitchen manager dashboard is designed to support strategic decision-making by providing insights into the kitchen's emissions for different food products. The dashboard is designed for the kitchen manager, who has the responsibility of buying food items and complying with the municipality's food strategy.

The kitchen manager dashboard should aim to fulfil requirement 1 and 2 from subsection 3.2:

(1) The manager must have access to ingredient emission data

(2) The kitchen manager must have access to customer feedback

The dashboard supports sustainably data-driven planning of menus by providing quantitative data visualizations and access to customer feedback. Additionally, the system features an ingredient explorer that supports the kitchen manager in picking environmentally and nutritionally appropriate ingredients. This section describes in greater detail how these 3 features are designed.

4.1.1 Data visualizations. To assist the kitchen manager in making informed decisions, the dashboard displays five years of historical CO2e emission data. The information is presented through interactive charts that enable an overview of emission per category during a given period. The chart design follows the principle of "Overview first, then zoom and filter, details on demand". Figure 8 shows the default overview where 5 years of historical emission data can be seen.

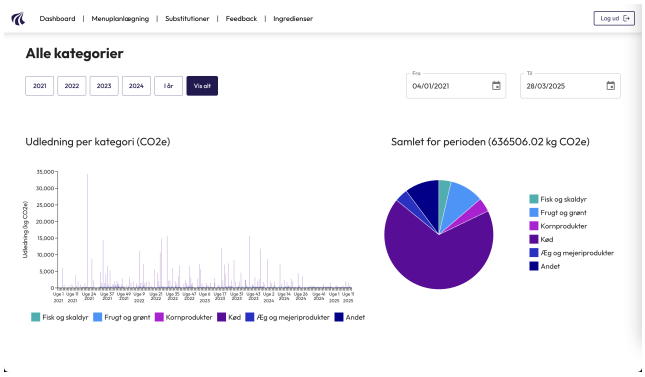

Fig. 8. Kitchen manager dashboard: overview first

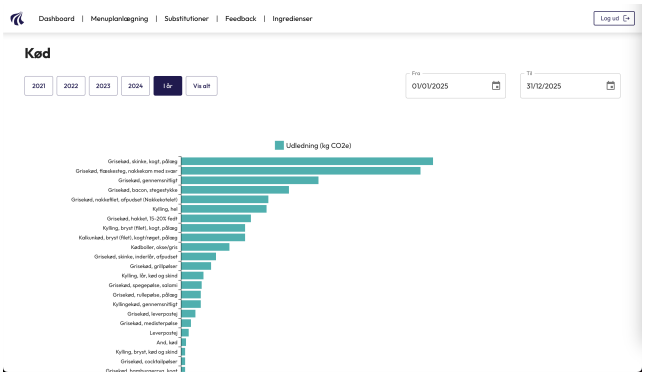

Fig. 10. Kitchen manager dashboard: details on demand

As seen on Figure 8, the dashboard features shortcuts that make it easy to explore different temporal ranges (”2021”, ”2022”, ”2023”, ”2024”, ”I år”, ”Vis alt”), where the last shortcut is the default time range. Additionally, in the top right side, the kitchen manager can also explore any custom time range, by using the date pickers to set a start and an end date for the data displayed. Figure 9 demonstrates how data can be explored in greater detail by using the shortcut to zoom in on the current year (”I år”).

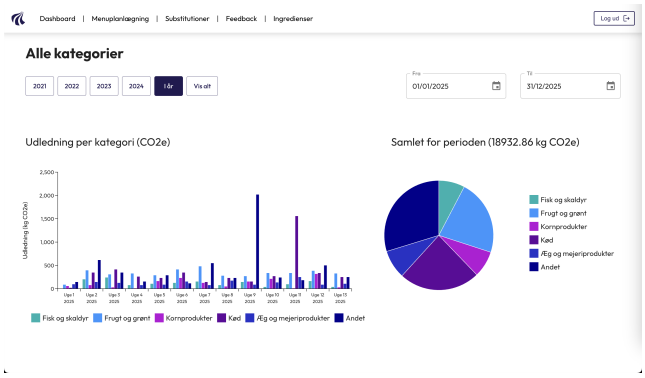

Fig. 9. Kitchen manager dashboard: zoom and filter

Enabling zoom and filtering, makes it easier to identify outliers in the emissions and thereby making it easier to act on the information provided. To provide even higher data granularity, each of the categories (marked using the 6 colors on the charts) can be clicked and the kitchen manager can get details on demand. An example of this can be seen on Figure 10.

4.1.2 Ingredient explorer. Based on the findings from interview 1 with the kitchen manager in subsection 3.1, it became apparent that a tool is needed that can support the kitchen manager in researching new sustainable ingredients. To facilitate this, the dashboard features an ingredient explorer, that allows the kitchen manager to list and compare the CO2e emissions and key nutritional information as carbohydrate, protein and fat for different ingredients. The ingredient explorer can be seen on Figure 11.

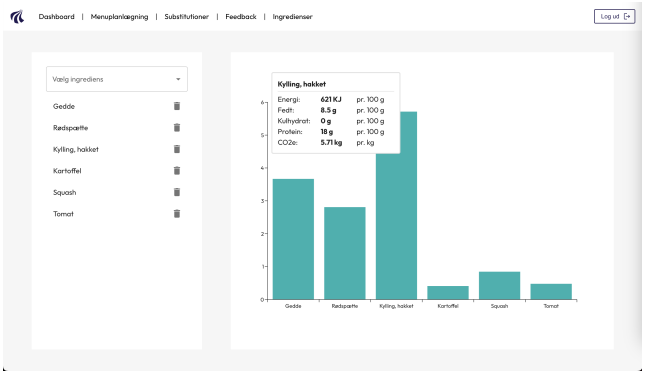

Fig. 11. Kitchen manager dashboard: ingredient explorer

4.1.3 Customer feedback. When canteen customers use the canteen dashboard to give feedback, the kitchen manager can see the feedback for each of the menus on the kitchen manager dashboard by navigating to the feedback page. The feedback page can be seen on Figure 12.

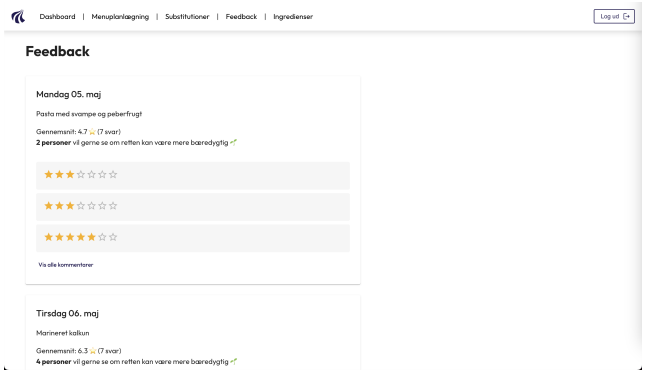

Fig. 12. Kitchen manager dashboard: customer feedback

4.2 Customer Dashboard Design

The customer dashboard is designed to provide meaningful visualizations of the emission of each day's menu and to provide canteen customers with a digital interface for providing feedback on the food served. Based on requirement 3 and 4 from subsection 3.2, we propose a design for the customer dashboard:

(3) The customers must be able to provide feedback on the menus

(4) The customers must have access to canteen emissions

Figure 13 shows 4 components which are referred to as *menu component* (top-left), *chart component* (top-right), *feedback component* (bottom-right) and *map component* (bottom-left). The *Friday component* differs in layout from the others. This can be seen separately on Figure 14 in subsubsection *4.2.5*.

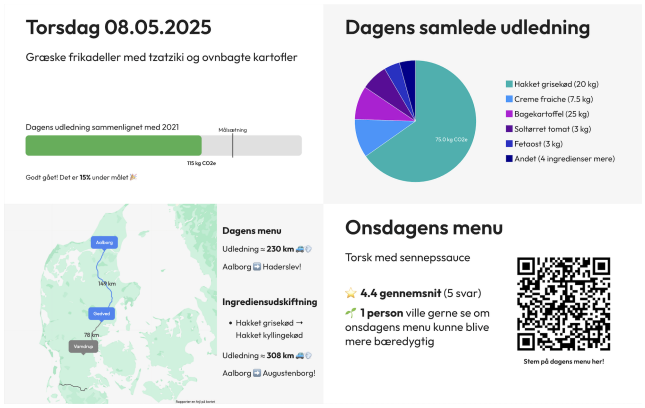

Fig. 13. Customer dashboard

4.2.1 Menu Component. The purpose of the menu component (top-left on Figure 13) is to display today's menu and its emission. CO2e emission in kilos is an abstract unit to relate to. It does not make much sense to display e.g. "115 kg CO2e emitted today" to users. However, related works suggest that direct measurement units can make sense to display if contextualized[21]. In this case, we display the unit but also a relative measure in percent. This percentage is based on a reduction goal of 25% from 2021 - 2025. This also makes use of *goal-setting*, as it has been shown to motivate users to "beat their past performance" and thereby possibly increase engagement[24].

The progress bar also displays a message that celebrates whenever the reduction goal is met or neutrally display the percent-wise excess if the reduction goal is surpassed. In case of the latter, the progress bar changes colour from green to yellow. When the reduction goal is met, the message is suffixed with a celebration emote and a supportive message to foster emotions of pride and satisfaction, with the purpose of encouraging long-term engagement[3].

4.2.2 Chart Component. The chart component (top-right on Figure 13) displays a quantitative data visualization in terms of a pie chart with the distribution of CO2e in kilos among the ingredients of today's menu. The pie chart lists the ingredients and their quantities in kilos to show the canteen customers what they are eating.

As the chart component displays the CO2e emission in kilos, it is important to contextualize the direct measurement unit[21]. Here, the unit is visualized as pie "slices", which makes it easier to understand, i.e. by seeing how large a slice of e.g. 10 kilos of CO2e is compared to the slice sizes of other ingredients.

Listing the ingredients is a deliberate *learning mechanism* that serves the purpose of giving the customers an idea of where the climate footprint comes from and to inspire the customers to make use of new ingredients when they cook themselves. This also aligns well with the kitchen manager's wishes to *"... share his knowledge"* and *"... inspire the next generation to cook more sustainably"* that we found in interview 1 in subsection 3.1.

If a menu is comprised of many ingredients, a pie chart will quickly become very densely populated by different coloured slices and legends and is therefore not very suitable for quantitatively displaying emission data for varying menus. To make the chart more suitable for quantitatively displaying emission data, only the 5 highest emitting ingredients are displayed. This also eases the comprehension of the data. The 6th slice is then a slice comprised of the remaining ingredients grouped together. This reduces the number of different colours and ensures that the chart legend is readable.

4.2.3 Feedback Component. To fulfil requirement 3 *Customers must be able to provide feedback on the menus*, we designed the feedback component (bottom-right on Figure 13). The primary task is to enable customers to provide feedback by scanning the QR code. To foster engagement, we display the current rating of yesterday's menu. By visualizing that other customers in the canteen participate in submitting feedback, we appeal to *collective thinking*. The hope is, that invoking a feeling of belonging to a group, encourage other canteen customers to submit feedback as well[5].

4.2.4 Map Component. CO2e in kilos is an abstract unit that most people do not have a relationship to. According to our findings for *quantitative and figurative data visualizations* in section 2, users with technical backgrounds tend to prefer quantitative visualizations, but customers in a canteen have varying backgrounds, emphasizing the need for a figurative data visualization[28]. Therefore, we add a figurative data visualization using a map (bottom-left on Figure 13) and a car trip metaphor. Here, the idea is to visualize the emission of today's menu by displaying a car

trip with a corresponding emission.

To further strengthen users' understanding of the emission, we employ the principle of a *"what-if" scenario*[32] by introducing an ingredient substitution, that models the effect of changing one or more ingredients in today's menu. For users that are already interested in the climate impact of known ingredients, the hope is that the ingredient substitution serves a mean of learning and by that, increases engagement[11].

The aim of the ingredient substitution is also to show the customers that small changes in the menu can have a big impact on the emission, which brings the customers closer to the decision-making process of the kitchen manager and shows that the kitchen staff's efforts to design sustainable menus has an impact, which aligns well with our findings from interview 1 in subsection 3.1, where we learn that the kitchen manager *"wants to communicate the sustainable efforts of the kitchen"*.

4.2.5 Friday Component. The canteen customers can choose to have a remote working day once a week and most employees choose to work remotely on Fridays. Therefore, the kitchen manager does not plan menus for Fridays as there usually are not many customers. Friday poses an opportunity to use the leftovers for the week's menus, so the Friday menu is always "The chef surprises". The layout can be seen on Figure 14.

With no planned menu for Friday, there is not much use for the chart component and the map component. Therefore, the dashboard has a separate layout for Fridays, which employs *gamification*, by introducing a leaderboard of menus where the week's menus are awarded medals based on feedback rating and emission. The leaderboard updates when feedback is received, so the customers can see the immediate change of medal distribution if a menu accumulates a better rating. This is an engaging way for the customer to see the effect of giving feedback. Visualizing all the week's feedback at once further strengthens *collective thinking*, as it becomes apparent that many customers participate in interacting with the system.

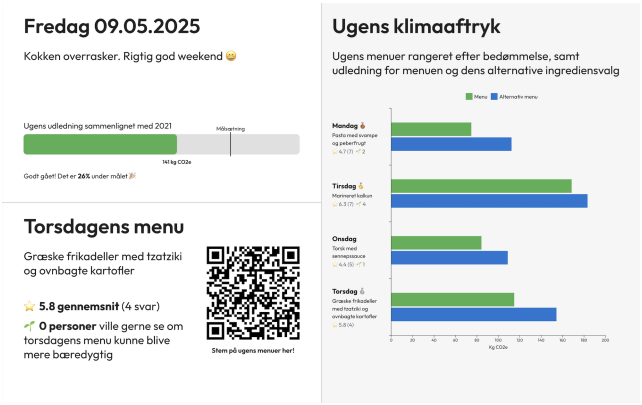

Fig. 14. Customer dashboard: Friday

The Friday component also makes use of *goal setting* by featuring a progress bar with similar properties as the progress bar on the menu component described in subsubsection *4.2.1*. The only difference is that the reduction goal is based on the average weekly emission from 2021, instead of the average daily emission from 2021. The direct measurement unit (CO2e in kilos) below the progress bar is *contextualized* when seen in relation to the menu emissions shown on the leaderboard.

The leaderboard consists of a horizontal bar chart, where each series represents a menu from Monday to Thursday. Each of the menus has 2 bars; one that displays the menu's emission and one that displays the alternative emission. Here, the x-axis displays CO2e in kilos but in this case the *unit is contextualized* by using the width of the bars to compare different menu emissions and the total weekly emission on the progress bars. By displaying the alternative emissions, the customers are reminded of the environmental impact of the *what-if scenario* of changing a single ingredient.

5. IMPLEMENTATION

This section presents the implementation of the developed system which is evaluated in section 6. The system is a client-server application built using modern web technologies that can run in any popular web browser environment. Additionally, the system is built as a web app offering the same experience as a platform-specific native application. This design choice allowed us to build a single application accommodating the needs of the kitchen manager while providing flexibility regarding the hardware serving the dashboard.

5.1 Stack

The described system is a Next.js application which is a framework built on top of React allowing for server- and client-side rendering of React components. This allowed us to implements a full-stack component-based architecture comprising the system of reusable components. The components was written in TypeScript which is a strongly typed superset of the more commonly known JavaScript which is also the destination language of the compiled TypeScript. On the client-side the browser serves as the runtime environment for executing the compiled TypeScript code while the server-side scripts are executed in a Node.js runtime environment. The system was hosted through Vercel who are the creators of Next.js.

5.2 Infrastructure

To build the back-end we chose to use Supabase which is a *back-end as a service* provider that made it possible to quickly set up user authentication and a PostgreSQL database for storing historical emission data as well as the menu feedback data collected throughout the deployment. The design of the components was based on the Material-UI react component library which allowed us to build a styled system in the short time span available. For the map-component as seen in Figure 13 we chose to use the Google Maps API through the Google Cloud Platform which made it possible to automate daily route generation from the menu emissions by calculating the distance from Aalborg to every city in Denmark.

5.3 Data

The historical emission data visualized on the kitchen manager's dashboard (seen in Figure 8, Figure 9 and Figure 10) is based on 5 years of invoices from the canteen's suppliers, where product lines have been classified as food items of different quantities. The system for classification was developed during the preliminary study[20]. The invoices were acquired from the municipality's sustainability controller and in total, 21.654 product lines

were classified. The daily menu emission data used in the customer dashboard (seen on Figure 13) was inserted manually through the weekly menus uploaded to the system by the kitchen manager. To calculate the daily emissions we used the same CLCA database on which we built the system in the preliminary study[20] to ensure consistency.

5.4 Hardware

To display the dashboard we used a large television (85") placed centrally in the canteen. We used a Raspberry Pi with the operating system FullPageOS, which is a lightweight Linux distribution customized to open a browser instance of the system dashboard on boot, to minimize technical errors during the experiment. This should be understood as in case something went wrong, the kitchen manager would only be required to unplug and replug the Raspberry Pi. To allow updates to the system without the interference of the kitchen manager, a cron job was used to force an hourly reload of the browser.

6. EVALUATION

This section presents the evaluation of the system's impact on the kitchen manager and the customers. The findings were collected through a customer questionnaire and semi-structured interviews with both customers and the kitchen manager. Each subsection presents the method and the findings along with an interpretation of the data.

6.1 Deployment

The system was tested over a period of five weeks. During the five weeks of system deployment, we received menus once a week from the kitchen manager which we processed weekly to prepare the data to be displayed on the customer dashboard during the following week. We did not intervene during deployment. However, we instructed the kitchen manager to contact us if any problems or questions occurred. During the last week of deployment, we went to the canteen to conduct the questionnaire and interviews. During deployment, we collected feedback from the customers regarding the daily menus, which we use to reason about the usability of the system in subsubsection *6.2.3*. In total, we collected forty-nine records of menu feedback spanning nineteen menus which we argue is a low amount of feedback given an estimated average of a hundred daily customers by the kitchen manager's account. Figure 15 shows how the customer dashboard is placed in the canteen.

Fig. 15. Customer dashboard seen in the canteen

6.2 Customer Questionnaire

Responses to the questionnaire were collected via a Google Forms link accessed through a QR code placed on canteen tables, as well as by approaching customers as they were leaving the canteen. The questionnaire consisted of eight Likert-scale questions rated from 1 (strongly disagree) to 7 (strongly agree), along with one open-ended question allowing for a free-text response about how the customer would like to see future improvements in the canteen. A total of 18 customers answered the questionnaire and while the sample size is limited, the responses provide useful insights into the perception and impact of the dashboard.

In order to evaluate the responses to the questionnaire we calculated the mean score, the standard deviation and the percentage of answers larger than four, which we will refer to as positive answers. These metrics helped us identify the average level of agreement and provide insight into how positively or negatively respondents perceived each statement. The results of this analysis are presented on Figure 16.

	Questions	**Mean**	**SD**	**≥ 5**
1	I am interested in my own climate footprint	5.67	1.78	72%
2	I am interested in the canteen's climate footprint	5.28	1.64	72%
3	I like to have a screen in the canteen displaying the daily menus emission	5.28	1.56	67%
4	I think it is easy to understand the information about the daily menus emission	4.94	1.63	50%
5	I think it is easy to give feedback about the daily menu	4.06	2.04	44%
6	Being able to see the ingredients of the daily menu has made me consider using new ingredients when cooking	3.67	1.81	39%
7	I am satisfied with the canteens climate footprint of the food being served	4.72	1.23	67%
8	I am satisfied with the taste of the food being served	4.83	1.72	67%

Fig. 16. Results of the questionnaire including mean score, standard deviation and percentage of positive answers.

6.2.1 User interest. In Q1 and Q2, we asked the customers to rate their interest in their own climate footprint and in the canteen's climate footprint, in order to evaluate the users' motivation for using the system and the relevance of providing eco-feedback within a canteen context. The results indicate that customers are generally interested in both their personal and the canteen's climate footprint. The percentage of positive answers and the moderately high standard deviation indicate that many users strongly agreed with the statements.

6.2.2 System acceptance. In Q3, we asked the customers to rate whether they liked having a screen displaying the daily menu emission, in order to evaluate the acceptance and perceived value of the eco-feedback system. The results indicate that customers are generally interested in seeing the daily emission of the canteen. The percentage of positive answers and moderately high standard deviation indicate that many users strongly agreed with the statement.

These results might be explained by the users' general interest in sustainability.

6.2.3 Usability. In Q4 and Q5, we asked the customers to rate the ease of understanding the emission information and the ease of giving feedback, respectively. These questions were aimed at understanding the limitations of the system design. The results of Q4 indicate that users generally understood the information; however, the percentage of positive answers and moderately high standard deviation indicate that a considerable part of users were either neutral or found it difficult to understand the information. The low percentage of positive answers and high spread of Q5 similarly indicate that a considerable amount of customers found it difficult to give feedback. When we approached people to participate in the questionnaire we found that a lot of customers did not bring their phone to lunch which is required to scan the QR-code. This finding might help explain the relatively low amount of feedback received during the experiment.

6.2.4 Behavioural impact. In Q6, we asked the customers to rate whether seeing the information had made them consider using new ingredients at home. The question was aimed at assessing early-stage behaviour change and determining the impact of the system. The results indicate that the impact regarding behaviour change is limited, although the percentage of positive answers indicates some impact. These results might be explained by the difficulty in understanding the information on the screen and users' existing interest in sustainability.

6.2.5 Canteen performance. In Q7 and Q8, we asked the customers to rate the level of satisfaction with the canteen's climate footprint and the food being served, respectively. These questions were aimed at understanding the customers' attitude towards the kitchen. Although we have not established a baseline for comparison, it helps us understand the correlation between taste and sustainability. The results suggest moderate to high satisfaction in both areas, which may indicate that sustainable practices have not negatively affected the perceived quality of the food and that there is a general satisfaction with the canteen's performance

6.2.6 Comments. The last question of the questionnaire was an optional open-ended question about areas of improvement answered in free-text. Of the eighteen respondents, six answered the open-ended question with one or multiple comments. Five of the answers were related to the food, while two of the comments were about the dashboard.

Of the five answers related to food, one person wrote that they would like more meat, another noted that the food contained a lot of salt and oil, and two stated that they would like less meat in the canteen. One respondent wrote:

> *"I primarily eat vegetarian and think that the canteen have improved in offering vegetarian alternatives and the salads are good, creative and inspiring."*

This supports the evaluation of the canteen's performance and might indicate the need for a feedback system in the canteen. Interestingly enough, we later found out that the system has had implications for the salad bar, but more details on this can be seen in the final interview with the kitchen manager, particularly subsubsection *6.4.2*.

Of the two answers related to the dashboard, one customer suggested displaying a familiar reference menu to compare the daily menu against, in order to better determine the level of sustainability. Another customer wrote:

> *"I don't understand the component in the bottom right corner (the feedback component) showing another day's menu."*

This comment could help explain the high spread among the answers related to the usability of the system.

6.3 Customer Interviews

The semi-structured interviews were conducted during a four-hour period within the canteen's open hours. The participating customers were selected by approaching them as they were leaving the canteen. The interview consisted of six main questions, which participants were encouraged to answer freely and to elaborate on. A total of nine customers were interviewed in this evaluation. The questions asked were:

(1) Do you care about CO2e?
(2) Did you understand the data on the screen?
(3) Did you learn anything by looking at the screen?
(4) Are you satisfied with the canteen's climate footprint?
(5) Are you satisfied with the taste of the food served in the canteen?
(6) Do you have any suggestions for improving the canteen?

In order to evaluate the interviews, we conducted a pragmatic thematic analysis of the responses, identifying recurring themes and sentiments. This analysis helped us gain a deeper understanding of the questionnaire results and provided new insights into limitations and areas for improvement in the system.

6.3.1 User interest. The analysis showed that all participating customers expressed some interest in sustainability, supporting the findings of subsubsection *6.2.1*. Three of the customers stated that they work with sustainability, indicating that the user group is predisposed toward sustainable practices. This may help explain the relatively low behavioural impact we found in subsubsection *6.2.4*.

> *"I am interested in it and use public transport but it is hard to understand where my everyday climate impact comes from. It would be nice if it was more transparent."*

6.3.2 Usability. The analysis revealed that all participating customers understood the information on the dashboard, which contrasts with the findings from subsubsection *6.2.3*. The responses regarding the dashboard were mostly centered around its overall visual impression, with a few comments about specific components. Four customers specifically expressed excitement about the map component, while four different customers said the dashboard looked simple and comprehensible. Two customers expressed confusion about the feedback component, as it displays the feedback from the previous day. This could explain why the ease of understanding did not score higher in the questionnaire.

> *"It is difficult to understand that there are two menu's on the screen, but i love the map and being able to compare the distance driven from day to day."*

6.3.3 Behavioural impact. The analysis showed that six people claimed to have learned something during the experiment, while three said they had not learned anything new or surprising. Among those who said they learned something, most highlighted learning

about the emissions of specific ingredients such as beef or avocado. One customer was surprised by the emissions of food in general. Although we did not find strong evidence of behaviour change in subsubsection *6.2.4*, the interviews suggest that participants learned new things, which might later influence their behaviour.

> *"Vegetarian monday and fish wednesday makes sense. That is something that really matters and it becomes very visible that it has an impact."*

6.3.4 Canteen performance. In the customer interviews, we found that seven customers expressed satisfaction with the canteen's sustainability efforts. The answers varied a lot and displayed no apparent theme. One customer noted that the dashboard had given them a higher acceptance towards legumes, while another noted that it was their impression that customers, in general, found the canteen's sustainability efforts important, although the longest line is always when they serve burgers and fries. These answers support the findings in subsubsection *6.2.1* about user interest in sustainability, although they also highlight that cultural aspects are important in reducing CO2e and that behaviour change is a long-term process. Although most customers were satisfied with the canteen's sustainable effort, one customer said that the canteen should serve two weekly vegetarian menus as a statement on behalf of the municipality, while another noted that they were unaware of the canteen's sustainability goal and thought vegetarian days were an initiative to accommodate vegetarian employees. This highlights the need for clearer communication between the kitchen staff and the canteen customers, as that might change customers' attitudes towards the canteen.

> *"I don't know much about it (the canteen's emission). I actually thought vegetarian days were for the young vegetarians."*

The analysis further showed that nine participants expressed direct satisfaction with the food served in the canteen. Of the nine participants, six highlighted that the food was varied, while two customers noted that they looked forward to trying the vegetarian dishes. This indicates that customers are open to suggestions and appreciate the efforts of the canteen.

> *"The food is is good, varied and it shows that they think about what they serve."*

While these results were somewhat more positive towards the canteen than the results from subsubsection *6.2.5* regarding the canteen performance, they support the findings from the questionnaire of a general satisfaction among customers towards the canteen's performance in serving sustainable and tasty menus.

6.3.5 Comments. In the interview, we asked people for any additional suggestions for improvement regarding the canteen or the system. Through this analysis, we found that two people commented on the physical environment of the canteen, which they found to be noisy and cluttered. The physical environment of the canteen might be an important factor in the customers' perception of the canteen and could help explain the difference in attitude between the interviews and the questionnaire. Three of the customers used the time to compliment the canteen for their efforts, with one customer noting that the canteen is doing a good job and shows a willingness to improve. This indicates that the sustainable efforts of the canteen have not gone unnoticed by the customers and that there is some level of successful communication between the customers and the canteen. Additionally, we found that there was an existing system for handling food waste in the canteen. The customers explained that customers could approach the canteen and buy leftover food to bring home. In total, two customers expressed a desire to digitalize the system in order to clearly communicate how much food was leftover, as the customers were often afraid to approach the canteen staff to avoid disturbing them. This indicates the need for a digital system for communication between the canteen customers and the kitchen staff.

6.4 Kitchen Manager Interview

To evaluate the impact of the system, we conducted an interview with the kitchen manager, with emphasis on whether his understanding of emissions has changed, whether the system has given rise to behavioural change among the staff and/or the customers and whether the kitchen manager thinks that using the system is easing the process of designing sustainable and well-tasting menus.

6.4.1 Understanding of sustainability. The first thing we were interested in knowing, was how and to what extent the system had supported the kitchen manager in getting insights into the kitchen's emission.

> *"We can see on the progress bar that we're staying below the target every day, which we normally don't have access to monitor"*

The progress bar has served as a tool for the kitchen manager to understand the environmental impact of the different menus served on a day to day basis, which he appreciated, as this is not something they have been able to do before. We asked if using the system has taught him something new about the climate-impact of different ingredients and not just the menus as a whole. The kitchen manager responded:

> *"It's become very ingrained in us (to consider emissions), so now we're used to designing menus this way. We generally know which ingredients are climate-friendly. But it's been nice to get confirmation that we're doing it right"*

This suggests that even though we provided tools for in-depth analysis, i.e. through the charts and the ingredient explorer, the main thing of importance for the kitchen manager was actually to get validation of the impact of his sustainability efforts and not so much to gain new insight into what ingredients to use and not to use.

We followed up by asking whether it was the kitchen manager's impression that the customers gained a better understanding of the efforts the canteen staff put into sustainable practices:

> *"Quite a few people jokingly say, 'Isn't there going to be some meat soon?'"*

The fact that customers suggested that there is room, emission-wise, for more meat, shows that they now consider the canteen emission, which indicates that the customers reflect on what food is served from another perspective than solely personal preference.

6.4.2 Impact on behaviour. We asked the kitchen manager whether using the system has changed any behaviour among him and the staff. He mentions that he was pleasantly surprised to see how the pie "slices" became more uniform as he toggled between viewing 2021, 2022, 2023, 2024 and 2025 data, indicating that the emissions had moved from primarily originating from meat in 2021

towards originating from more varying food categories in 2025. Instead of one big slice and a few narrow slices on the pie chart, the slices now have a more even size. He showed this development to the staff and it was received with great enthusiasm. When asked about what effects this insight had, the kitchen manager answered:

> *"The diagrams (pie chart) made us change the salad bar - customers get much more varying mixed salad now. Before, we tried to hide it a bit, but now we try to include as much as possible"*

This led us to ask whether it is the kitchen manager's impression that customers have changed behaviour as well:

> *"I think so - a lot of people have come and asked for recipes. We've printed quite a few, and now we can do that."*

As an experienced chef, the kitchen manager had mostly been planning meals and procuring food based on intuition. Now, however, the kitchen manager has been writing down exact ingredients and quantities, which made it easy to hand out a recipe if a customer asked for it.

6.4.3 Future work. We are interested in understanding how we can further support the kitchen manager in balancing the taste and emission of meals. He highlights the progress bar as being particularly useful for this:

> *"The goal for us has been to stay under the target, so I've chosen climate-friendly ingredients. For the vegetarian moussaka, I considered not adding so much cheese, but when I saw the pie chart with cheese, I almost regretted it (putting it in). Luckily, I could see (on the progress bar) that I was still under the target."*

When we ask about whether the system has helped him getting closer to the customers by taking their feedback into account when deciding what to put on the menu:

> *"If there had been 50 responses (to a menu), we could have used the data, but when only 3 people respond, you can't base your changes on that."*

We ask why he thinks that the customers are not providing more feedback. The kitchen manager points to the fact that the customers are busy enjoying their break during lunch:

> *"A lot of people stop by in the morning and take a look, compared to lunchtime. Also when people are heading home – not so much during the break."*

7. DISCUSSION

While our project involved the iterative design of specific dashboard components, our evaluation primarily concerned the real-world impact of deploying the eco-feedback system in the canteen. Rather than evaluating the effectiveness of individual design elements, the evaluation reveals how introducing a visible, interactive system affected the kitchen's routines and the customer engagement and their perceptions of sustainability. In this discussion, we reflect on the broader implications of embedding such a system into a canteen or a similar context.

The deployment of the system made the canteen's CO2e emissions visible and accessible to both staff and customers. This visibility appears to have given rise to new forms of reflection and engagement. The kitchen manager noted that customers began to ask questions about the food's climate impact — even jokingly suggesting that there was now "room" to reintroduce more meat, since emissions were under the reduction goal. While this illustrates an increased awareness of sustainability in the canteen, it also reveals a side effect: when performance is framed as "good enough" it may unintentionally justify less sustainable choices. This suggests that eco-feedback systems must carefully define the success criteria, merely defining success as staying below the reduction target has had unintended consequences in our case.

The system also fostered some unexpected customer behaviour. The kitchen manager reported that several customers had started asking for recipes after the system was deployed. This example suggests that even simple interventions, as displaying which ingredients comprise today's menu, can inspire spontaneous knowledge-sharing and environmental curiosity.

The system also gave the kitchen manager access to tools for exploring kitchen emissions historically and comparatively. While this did not significantly increase his understanding of sustainable ingredients (as he already possessed strong prior knowledge), the validation of the kitchen staff's progress was highly motivating. For instance, observing more evenly distributed pie slices on the pie charts across years led to direct changes in how the salad bar was composed. This demonstrates that eco-feedback systems can serve as motivational and confirmatory tools, even in cases where deep sustainability knowledge already exists.

Despite the positive reception, the feedback component of the system saw limited use — only 49 submissions across five weeks. Interviews and observations revealed a key issue: many customers do not bring their phones to lunch, which made it impractical to scan QR codes and submit menu feedback. This highlights an important limitation of optional feedback mechanisms in relaxed social contexts like canteens. Future systems might explore passive or ambient data collection, or staff-facilitated feedback processes, to overcome this barrier.

Ultimately, our project shows that the value of eco-feedback systems lies not only in their interface design, but in how they are situated within everyday routines, physical spaces, and organizational cultures. The placement of a screen and the degree of integration with existing workflows all shaped how the system was received and used. This suggests that researchers working with eco-feedback systems should consider not just "what" to display, but also "where", "when", and "how" it becomes part of the user's environment.

8. CONCLUSION

This project set out to investigate:

> *How can a digital system promote sustainable food choices by supporting both canteen customers and the kitchen manager in understanding and reducing food-related CO2e emissions?*

To answer this question, we developed and deployed an eco-feedback system that made menu emissions visible to both kitchen staff and customers, and enabled customers to provide feedback on the food served through a digital interface. By embedding the system into the physical environment of the canteen, we aimed to explore how emissions could be meaningfully communicated and acted upon in an everyday scenario.

Our evaluation shows that even a relatively simple system comprised of a screen displaying emission data and a feedback interface, can influence awareness, staff motivation, and engagement with sustainability. The kitchen manager used the system to validate and communicate sustainable practices, make adjustments to what food to serve, and reported that the system stimulated conversations about sustainable food choices between canteen customers and kitchen staff. Customers reflected on the emissions of their meals, engaged with the visualizations, and in some cases asked for recipes or offered suggestions on what to serve. These interactions suggest that making emissions visible can spark curiosity, support learning, and encourage behaviour change.

At the same time, our findings also highlight some challenges. Participation in the feedback system was limited, and some users interpreted "low emissions" as a reason to ask for more meat — a reminder that eco-feedback systems can produce unintended effects if success is framed too narrowly. Moreover, the effectiveness of such systems depends not just on their design, but on how they are situated within the physical environment, user routines and organizational cultures.

Ultimately, this project does not offer a definitive answer to how emission data can reduce CO2e emissions in a canteen, but it does demonstrate that such data, when made accessible and contextually meaningful, can play a role in fostering more sustainable food practices. Future research should continue to explore how digital tools can support sustainability not only through information, but through interaction, reflection and integration into everyday routines.

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