The Team

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Problem and Solution Overview

Most people would say they want to save money, and the average American spends 21% of their money – by far the largest percentage – on housing-related costs. These costs are divided into fixed expenses, such as rent and property taxes, and variable expenses, such as utilities. People also want to be more sustainable and environmentally friendly, with 85% expressing a desire for an eco-friendly home. However, it is difficult for people to find the knowledge and motivation needed to be eco-friendly. Decreasing utility consumption is one of the easiest steps towards achieving both decreased financial costs and increased eco-friendliness.

There are currently many barriers to efficient utility usage, amongst which are a desire for convenience, an absence of personal responsibility and accountability, a lack of conscious thought about usage, and delayed feedback. Our design solution addresses these problems by making the assumption that technology exists to enable a "pay what you use" system - that is, utilities are split not evenly but based on individual use - and then focusing on an informational, ambient hub that aims to use the social implications of such a system to create a sense of individual responsibility. The design also focuses on increasing the frequency and availability of information as well as awareness of what is currently being used and by whom.

Initial Paper Prototype

Overview
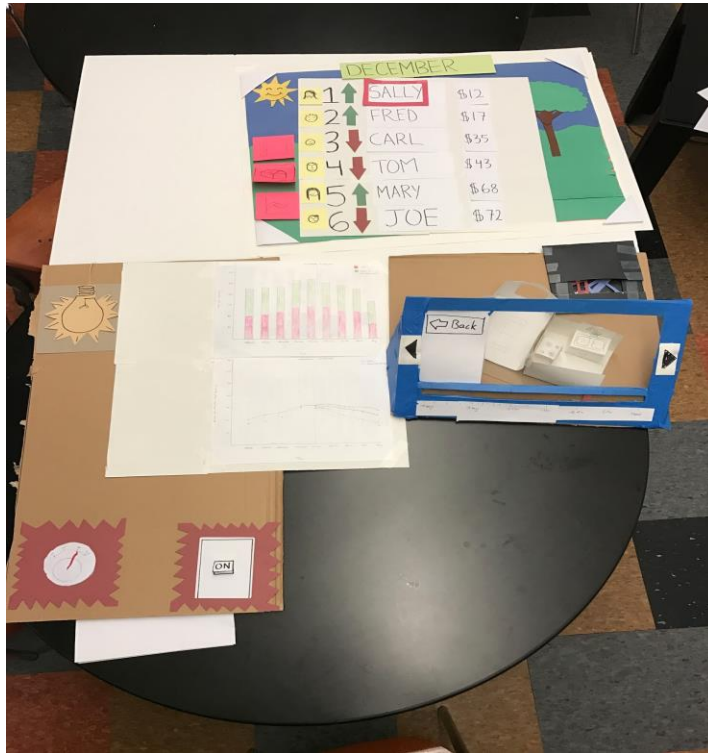
Task 1: Information: Compare and Understand Your Usage, Hold Everyone Accountable

The default view of the hub shows the house leaderboard, which compares housemates' usage since the beginning of the billing cycle to the present. It also shows how much each person owes, as well as if their usage is trending up or down. Sally is in the room, and since she is at the top of the leaderboard the hub reflects her efficiency with a lush green background. She taps on the graph icon to go to the graph page.
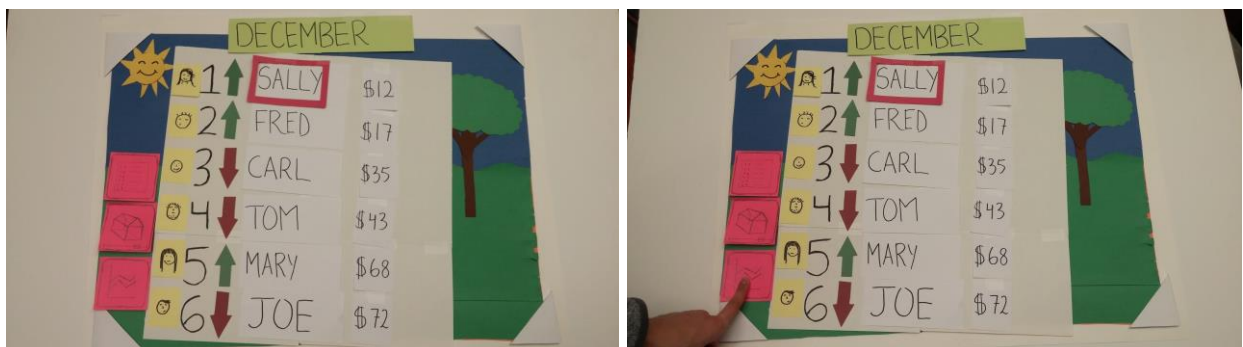
The graph page has detailed graphs for the currently selected housemate. The graphs include information about both previous and projected usage for all utility types.

She taps on the house icon to bring up the 4D house model, which will appear as a virtual model on the hub screen.
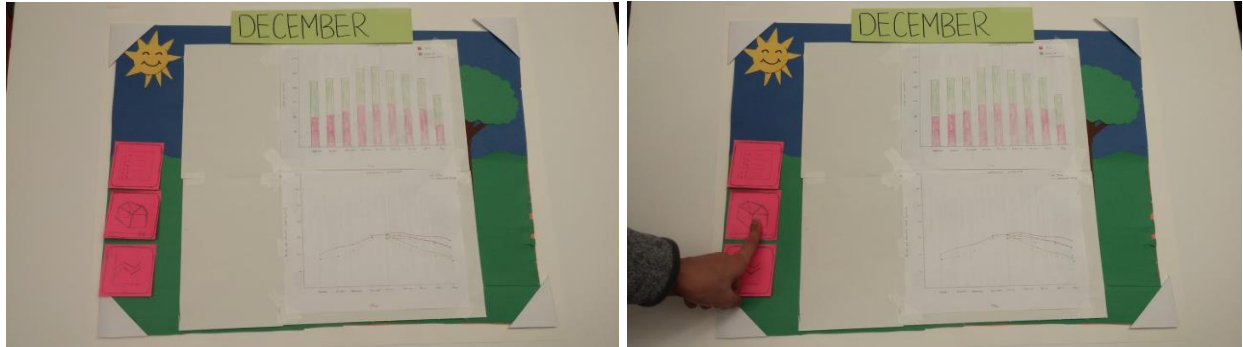

The 4D house model shows which housemate is currently using which appliances throughout the house. Each housemate is assigned a color. In this instance, the housemate signified by the blue color is using both the oven and the sink. Tap on the right and left icons, or swipe across the screen, to rotate the house model.

She slides the dial at the bottom to step back through time and see when each housemate was using any given appliance. Sally sees that around 15 minutes ago the red housemate was using the oven and the sink. This dial can go back anywhere from a few minutes to the start of the billing cycle. Here she can see that no appliances were being used about a week ago.
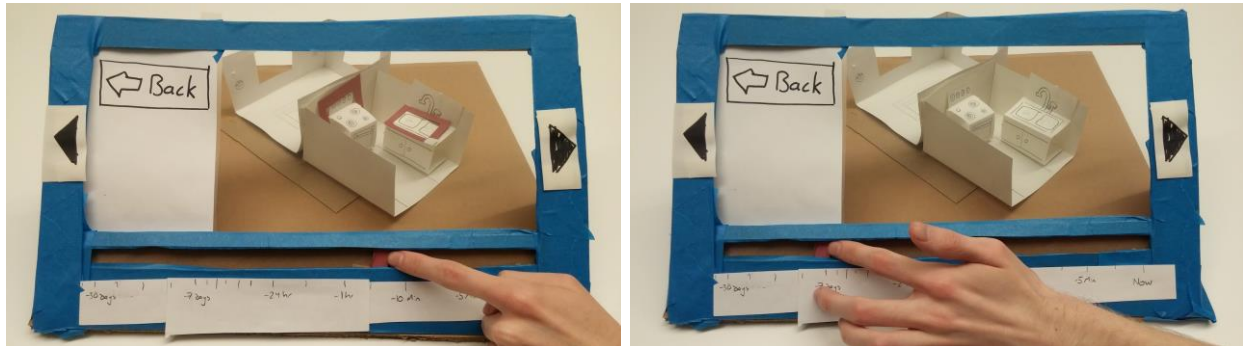
She taps on the back button to return to the leaderboard. Now Joe is in the room, so his name is highlighted. Since Joe's usage this month has been very inefficient, the background of the hub has changed to a dead and sad environment.
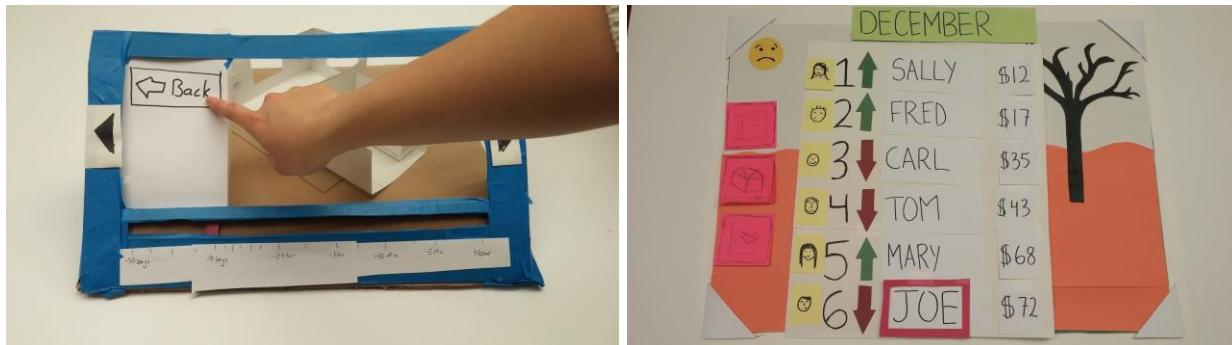
Task 2: Action: Control Appliances Remotely, Pay What You Use

The light is on, so the light switch is surrounded by a color representing which housemate (red) is currently using the device. A different housemate enters the room, the light switch changes to a dual color glow, representative of the two current housemates using the appliance.

One of the housemates uses voice activation to turn the light off on her way out the door. The light switch is no longer glowing. The red housemate enters the room again and uses voice activation to turn up the heat to 80 degrees. The thermostat glows red to reflect the current user.
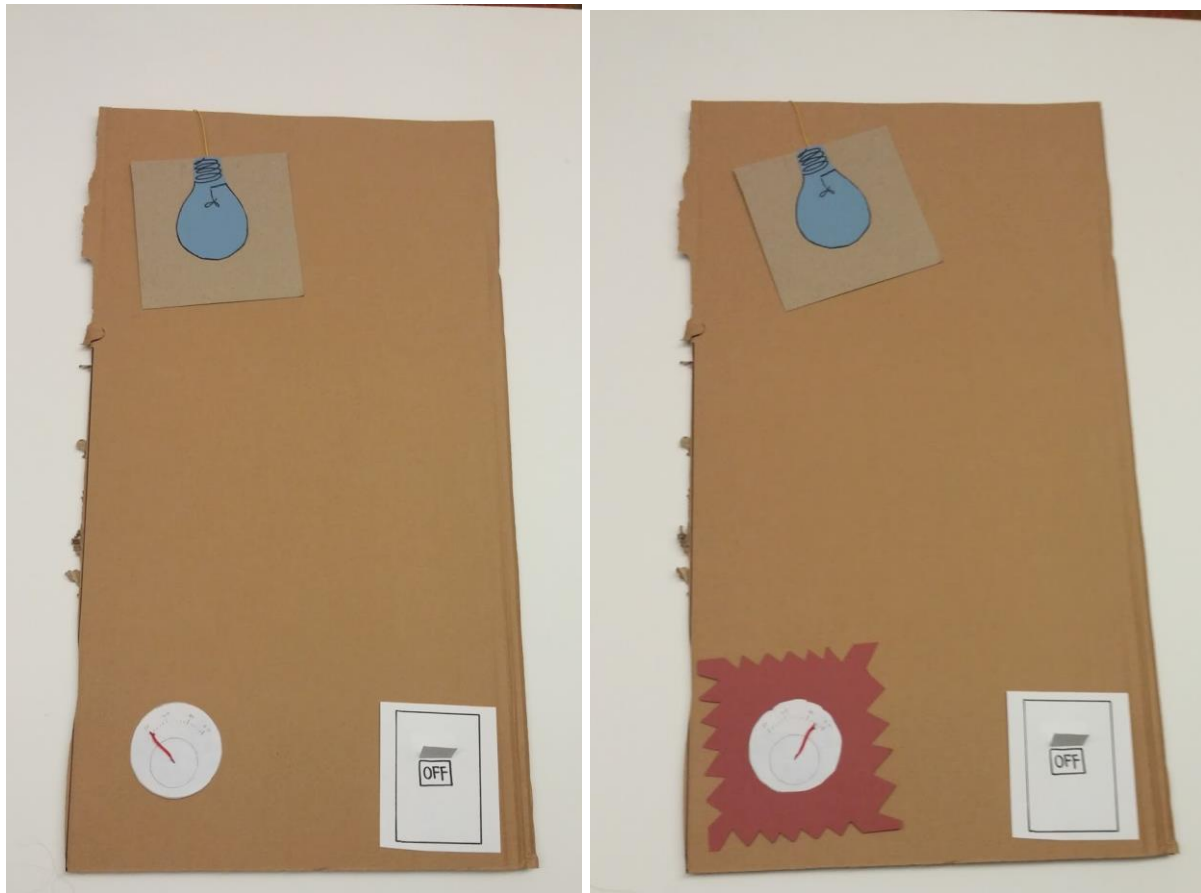
Testing Process

We conducted three usability tests. Our three participants were UW students, chosen because they were representative of our target audience. These participants were young adults living in shared housing where they knew their housemates. We conducted all of our usability tests in private CSE undergraduate study rooms to limit interruptions.
- Tracy - Facilitator
- Matt and Carl - Computers
- Carson - Note-taking

Each of our usability tests started with the facilitator explaining the following to the participant: the problem space we're focusing on, the purpose of our design and its context within the home, and what role we wanted the participant to take. The facilitator also explained that we were testing the

design and not the participant, and that the participant may leave at any time. The facilitator then defined three tasks the participant needed to attempt via the system. The tasks were chosen to span the "get feedback - process feedback - take action" usage cycle that we detailed previously. Because one of the tasks we chose to focus on is passive (*pay what you use)*, the second and third assignments we gave to our participants focused on subtasks that arise when you pay for utilities in a fair way.

1. Figure out why your bill is so high (*compare and understand your usage*).
2. Disable tracking temporarily for the oven (*pay what you use, in the context that you cook dinner for your housemates and you don't want to bear the cost of kitchen appliances*).
3. Disable tracking temporarily for Sally (*compare your usage and keep everyone accountable, in the context that if Sally leaves for the weekend she shouldn't be tracked and shouldn't be high on the leaderboard*).

We made revisions to our testing method after each of our tests. After the first test, we reorganized our components and redistributed roles amongst the "computers" to make the process more smooth and realistic for the participant. We found that our relatively large paper prototype made it especially difficult for the computers to make the interaction run close to realistic speed. Also after the first test, we found that we had not concretely defined when what it meant to complete a task. Therefore, we collectively defined what completion meant for each of our three tasks. This resulted in an overall improvement to our other tests. They ran much more smoothly since we knew when to end a task and move to the next. After the third test, we found that our continued refinement of our testing method resulted in the third test being quickest of the three usability tests. Although time to complete a test is not the best indicator of the quality of the test, time decreased for each test proving that each of the group members learned their roles better. One of our best decisions was keeping the same roles throughout the three tests. This made the tests run quicker and smoother. One future improvement to our testing method if we were to do another is we would randomize the order of our three tasks. The participants of our tests completed the second and third task much quicker than the first because they had learned our design better by then. By randomizing the order of the tasks we could eliminate some variability. For example, task 3 before task 2 could have helped the participant complete task 2 more than if task 1 were given to the participant before task 2.

Testing Results

Results from Heuristic Evaluation

We discovered many issues with our prototype from the heuristic evaluation, and we made a lot of revisions. In general, we just added a lot more screens, made the prototype larger, reduced clutter, and increased consistency. None of the screens had a help button, most of the screens did not have titles or labels, and only some of the screens had back buttons. This made it difficult both for the person to navigate and for them to tell what was going on. We added all of these things consistently to every page to increase user control and knowledge of the state the program is in.

We also changed some things not directly a part of the physical design, but instead in the way the human computers controlled the design. The first of these changes involved the house model, where we learned how users expected a touch screen to interact and adjusted our behavior accordingly. The more significant of these changes was a design-wide change, where we would have the object wiggle when a user taps on something that does nothing. This increases feedback and makes it significantly more clear to the user what is happening.

Some of the key revisions included:

Changing the leaderboard to increase whitespace, decrease clutter, and improve consistency.

Add a legend wherever colors are used in order to use recognition rather than recall.

Added a help button to every screen, and a help message to go with it.
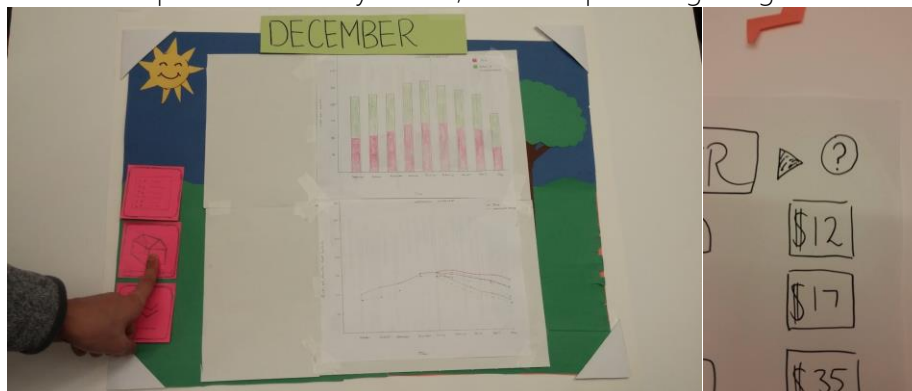
Results from Usability Test 1

The first usability test also provided a lot of areas to revise the prototype. The main changes from this test were based around the idea of having multiple ways to navigate the design. We noticed in multiple situations that the person testing would intuitively look for a way to accomplish a task in a place other than where we put it, which resulted in a confusing and unclear situation for him. To help this, we added multiple ways to accomplish the same task, rather than having only one for each. For example, a person can disable tracking for an individual appliance either by disabling it in the main list of appliances in the settings menu, or by tapping the appliance in the house model and disabling it there.

The other changes were generally about improving the ability for a person using the design to know what is going on. Although we had intended to add a help button to every page in the last revision, we did not do so for the house model page, which resulted in a lot of confusion for how to interact with it. Ensuring that every page had a help button improves both consistency and helps the person always feel like they can learn what they can do on any given page.
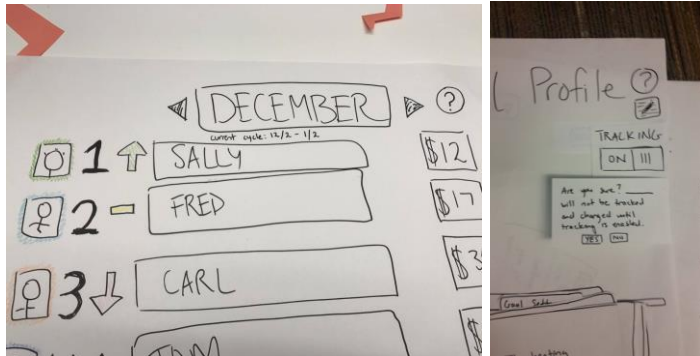
Some of the key revisions included:

Adding a help button to the house model page, giving information on what can be done
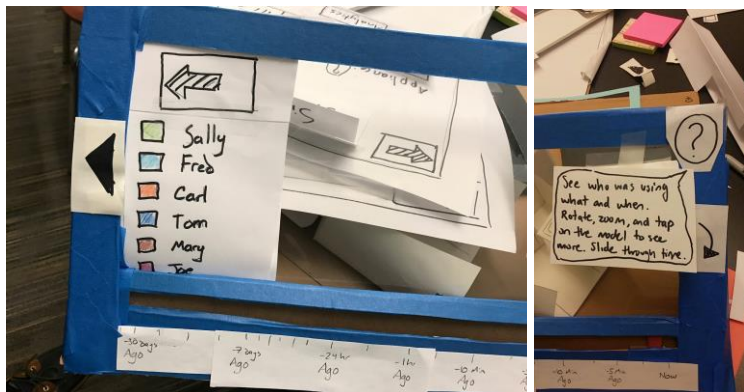
Provide a list of appliances in the settings menu so that there are multiple ways to navigate
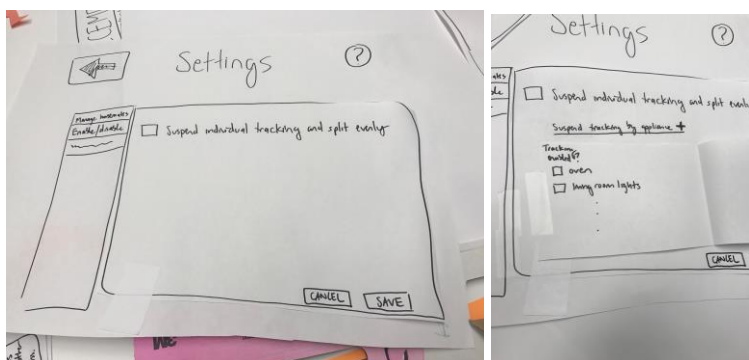
Provide a way to disable tracking for an individual on their profile

Results from Usability Test 2

Partially due to the large number of problems found and revisions made in the heuristic evaluation and first usability test, the second usability test did not find nearly as significant of problems. He was able to accomplish the tasks quickly and easily, and he usually understood the design and was able to click the help buttons when he didn't. The only revision made was to improve consistency, where one of the titles on the pages was in a box, so it looked like a button and he tried to click it.

Changed the "Analyze" title so it does not have a box around it
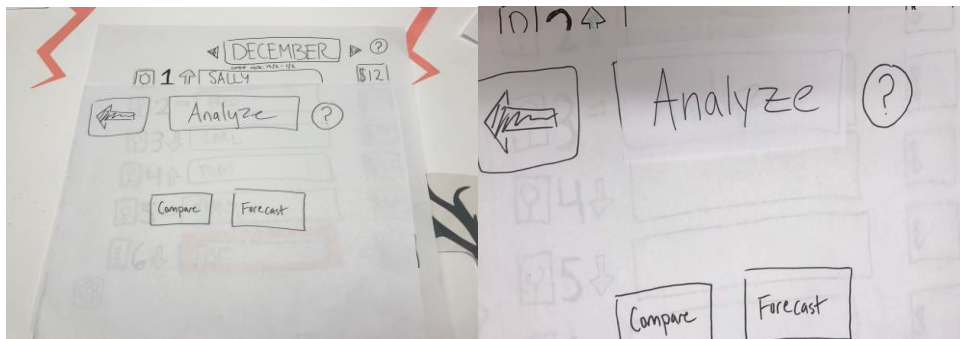
Results from Usability Test 3

Similar to the second usability test, the third usability test went smoothly and the only issues were minor ones. On the settings page, the person thought it was confusing and unclear that there was a save and cancel button, and they expected that any changes they made would have gone through immediately. By fixing this, we reduce confusion and also work towards our general goal of increasing consistency and reducing unnecessary clutter.

Removed the save and cancel buttons in settings, making it so changes are effective immediately
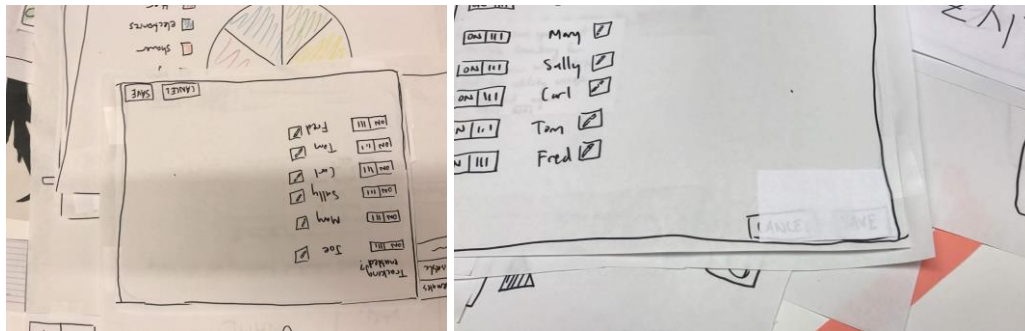
Final Paper Prototype

Overview

Task 1: Understand why your bill is so high (*understand your usage, pay what you use*)

The person walks up to the hub and sees that they have spent the most this month on utilities. This is portrayed to them with a sad background and the lowest ranking on the leaderboard.
They tap the house model button to see which appliances they have most often used in the past. When scrolling back through time, they notice patterns, such as leaving the heat on. For greater granularity, they pause at a particular time and see that they had the oven on.

The person then taps the on-screen oven to bring up details. They see that the oven was on for over 2.5 hours. From here, they may view graphs of oven usage by clicking the analytics button. By pressing the back button, the person returns to the leaderboard to find more information.
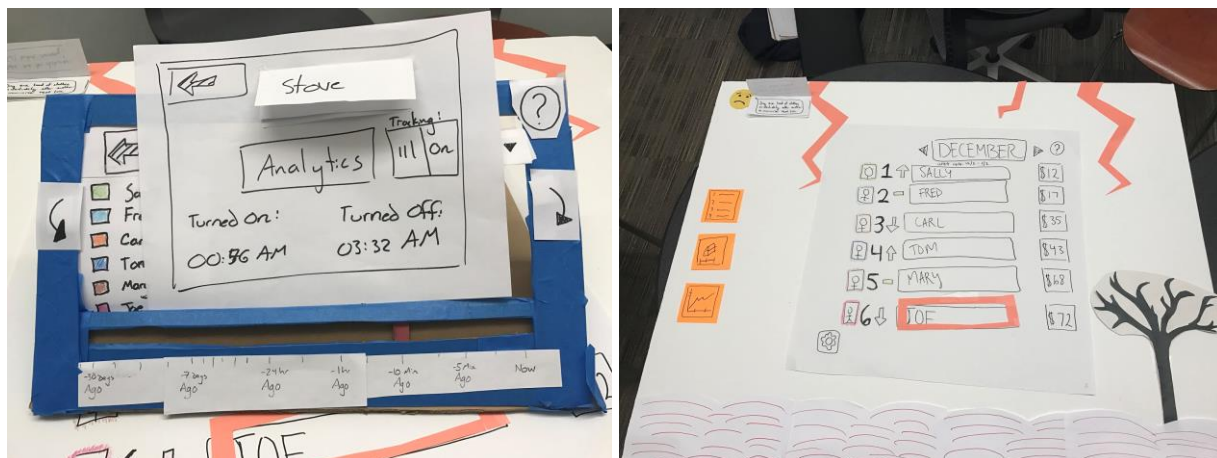
From the leaderboard, they select their name to view their profile. This profile displays the usage for the current billing cycle. Consistent with the 4D model, the graph shows they primarily used utilities on the oven and heater. By navigating to the recommendations tab, they can then view recommendations tailored to them based on their usage. The person now understand what caused their high bill as well as actions they may perform in the future to reduce it.
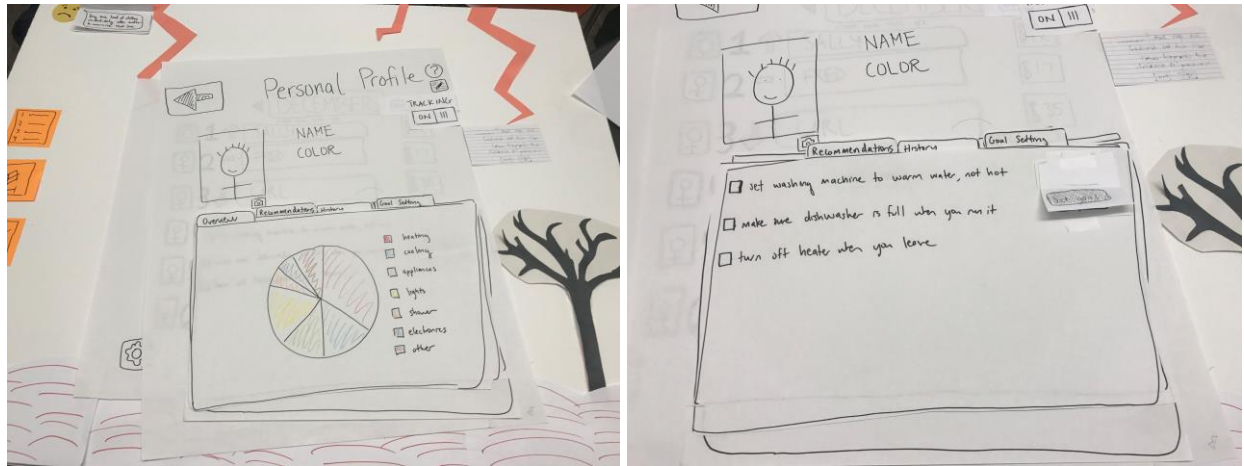

Task 2: Keep everyone accountable, compare your usage

Joe wants to see how he is doing compared to his housemates, especially since he is at the bottom of the leaderboard. He navigates to the analytics page and is presented with two options.
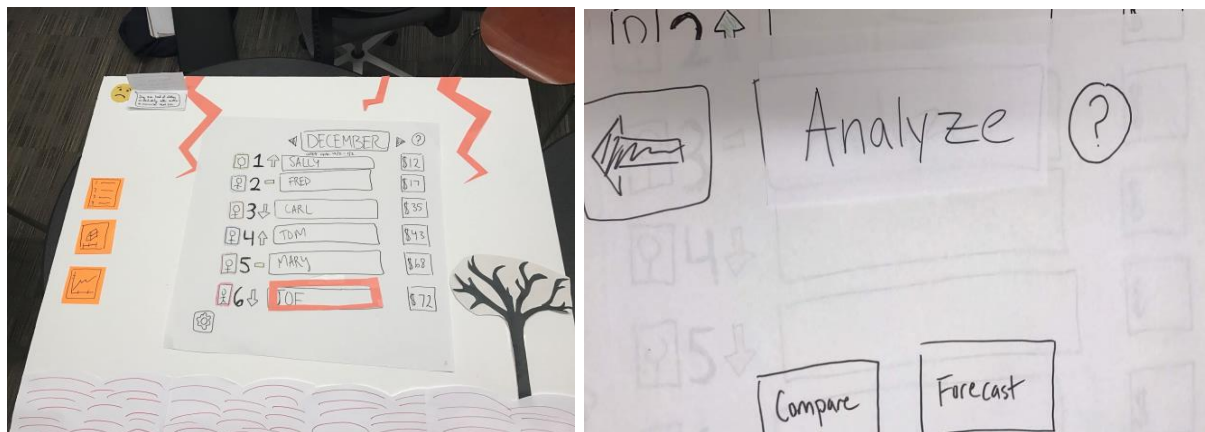
He chooses "compare" in order to compare himself with his housemates. This presents him with a relative pie chart of utility usage. He then compares his household to those near him in order to greater understand his usage. He does so via a dropdown menu.
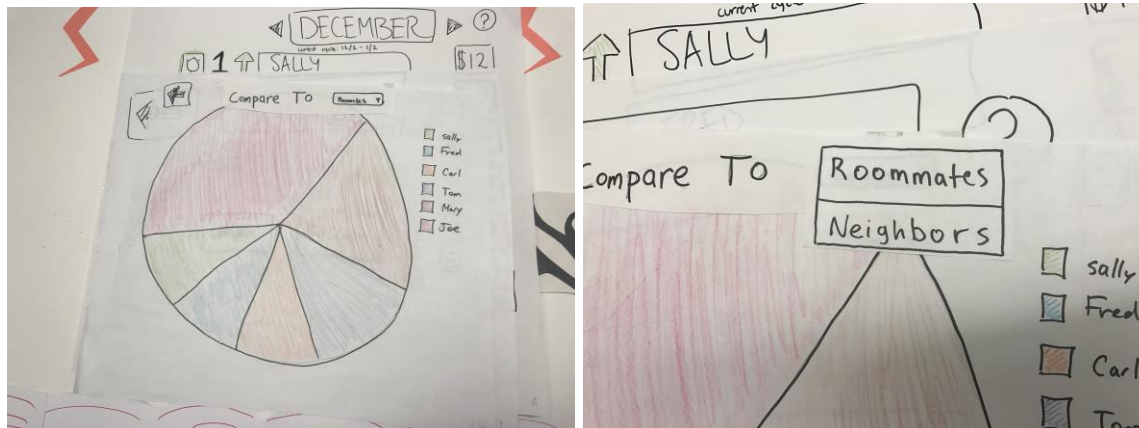
Joe now better understands their usage relative to both their roommates and neighbors which enables accountability through social pressure, since he doesn't want to be the worst one.
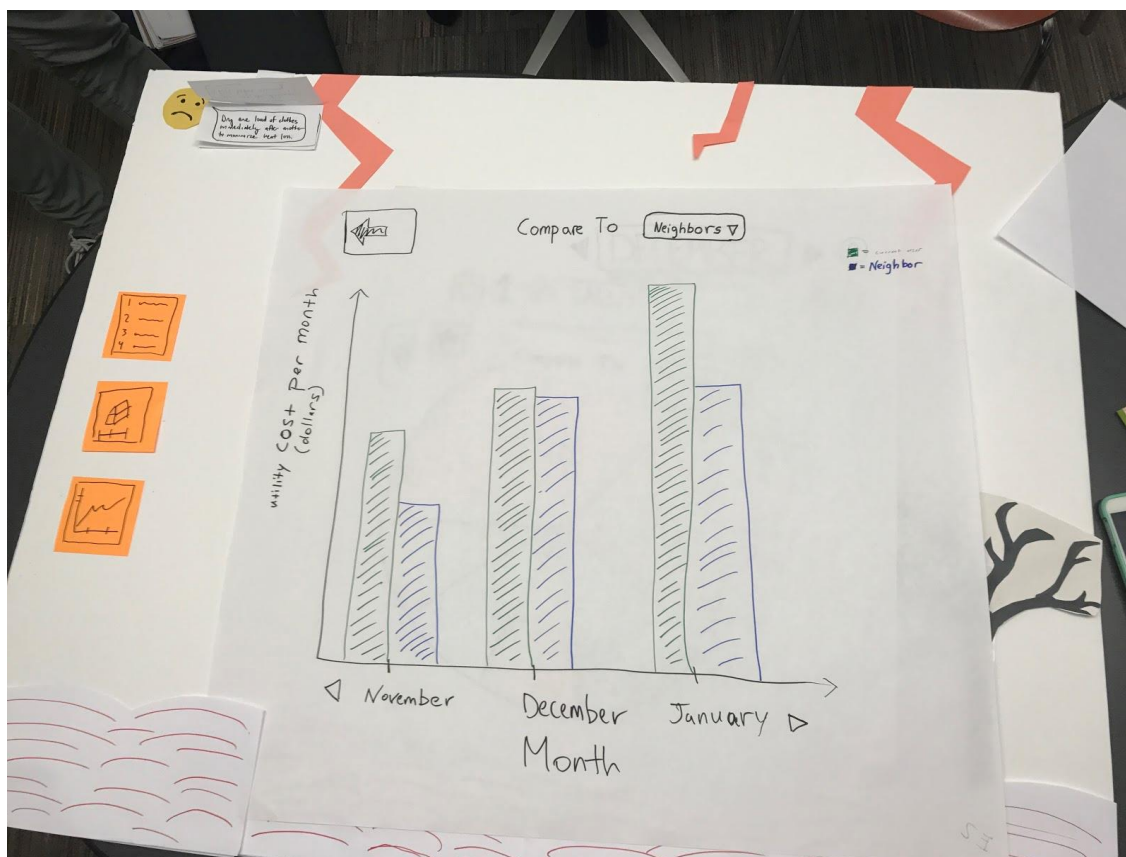
Digital Mockup

Changes from Paper Prototype

There were no major changes or decisions made to our design as we transitioned from paper to digital representation since feedback from TA's and the usability tests was mostly positive. We did make note of small aesthetic changes such as button layout and minimizing the use of colors unless necessary. Additionally, in the paper prototype we had a personified sun icon that gave utility usage tips. While these tips were helpful, we saw that in the usability tests people rarely tapped on the sun and so we decided to remove the icon. We felt that these changes would contribute to a minimalist and less distracting design, especially since our project is meant to be an ambient display. However, we did make some minor changes. In the legends for our compare graphs, we replace the box of color with a person icon filled with the person's corresponding color. We also made the settings navigation button the same size and shape as the leaderboard, analyze, and model navigation buttons. Another minor change occurred in the 4D model, where we made a horizontal legend to blend in better with the display. Generally, we made our design more minimalistic and consistent.

Task 1: Understand why your bill is so high (*understand your usage, pay what you use*)

The person walks up to the hub and sees that they have spent the most this month on utilities. This is portrayed to them with a sad background and the lowest ranking on the leaderboard. They tap the house model button to see which appliances they have most often used in the past.
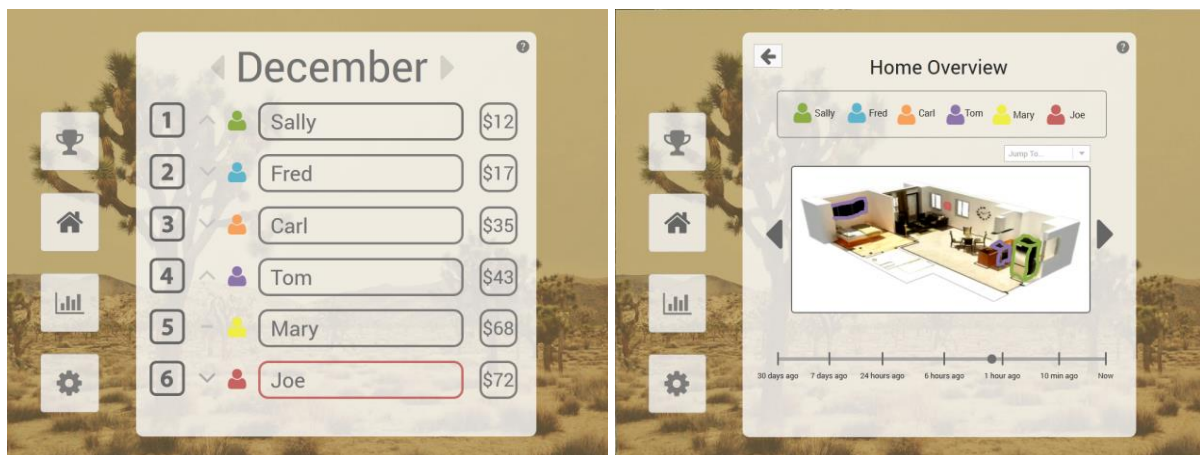
When scrolling back through time, they notice patterns, such as leaving the heat on. For greater granularity, they pause at a particular time and see that they had the oven on. The person then taps the on-screen oven to bring up details. They see that the oven was on for over 2.5 hours. From here, they may view graphs of oven usage by tapping the analytics button.
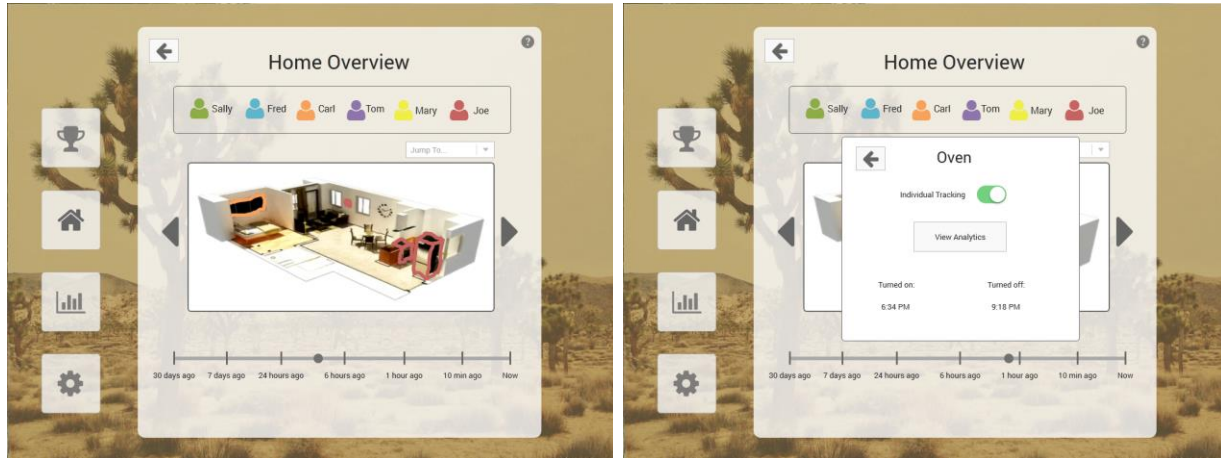

By pressing the back button, the person returns to the leaderboard to find more information. From the leaderboard, they select their name to view their profile. This profile displays the usage for the current billing cycle. Consistent with the 4D model, the graph shows they primarily used utilities on the oven and heater.
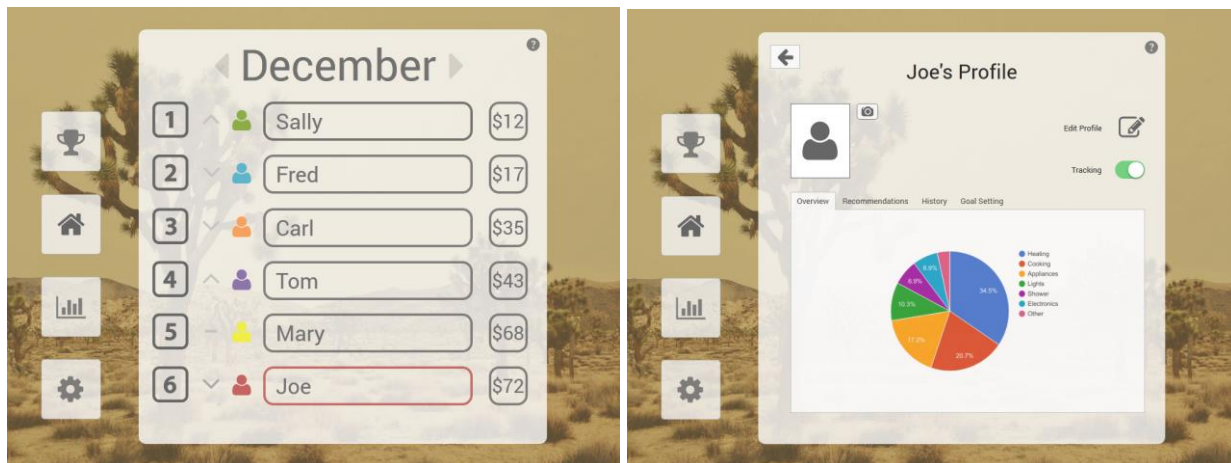
Task 2: Turn off tracking for the oven (*pay what you use, keep everyone accountable*)

Sally walks up to the leaderboard to see her name at the top, reflecting how she is individually very responsible about her utility usage. The lush green background represents her leaderboard standing. However, today Sally is cooking dinner for all her housemates and based off of the "pay what you use" functionality that creates a sense of individual accountability, all the utility usage in the kitchen will be charged to her even though she is cooking for other people. She thus wants to turn off tracking for the oven and split that charge evenly while she is cooking. Sally taps on the settings icon on the bottom left. She is brought to the main settings page, where she can manage tracking and adjust other settings for individual people.
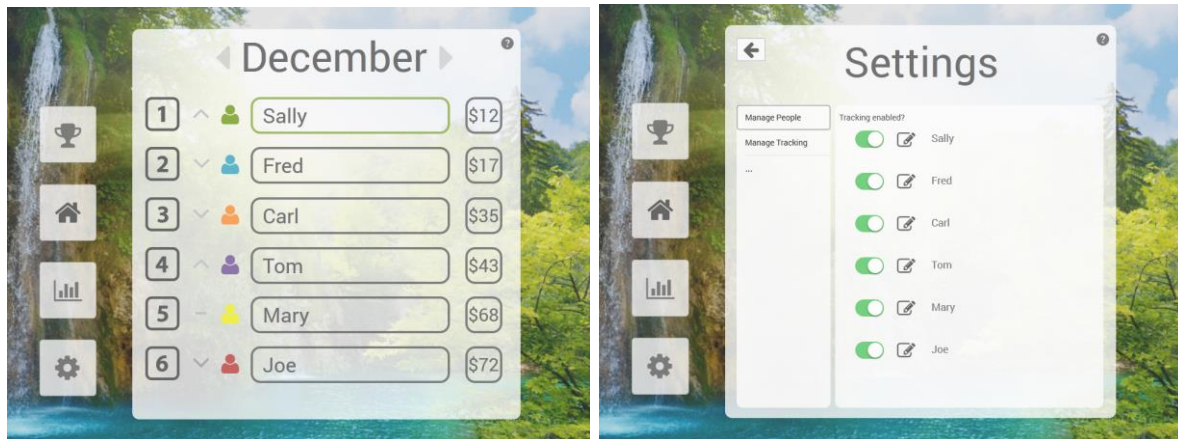
She taps on the "Manage Tracking" tab on the left. She is then brought to the page where she can manage tracking for utilities and appliances. She taps on the "help" icon next to "Suspend tracking for specific appliances to confirm that she is in the right place to disable tracking for the oven. She taps on the down arrow on the left and sees the list of appliances/utilities in the house and toggle buttons to enable and disable tracking for each appliance/utility.

She taps the toggle button for the oven. Sally has succeeding in splitting charges for the oven evenly amongst her housemates until the toggle is turned back on. All other utilities and appliances in the house are still on "pay what you use" mode to create personal accountability, and the oven is fairly off of that mode.
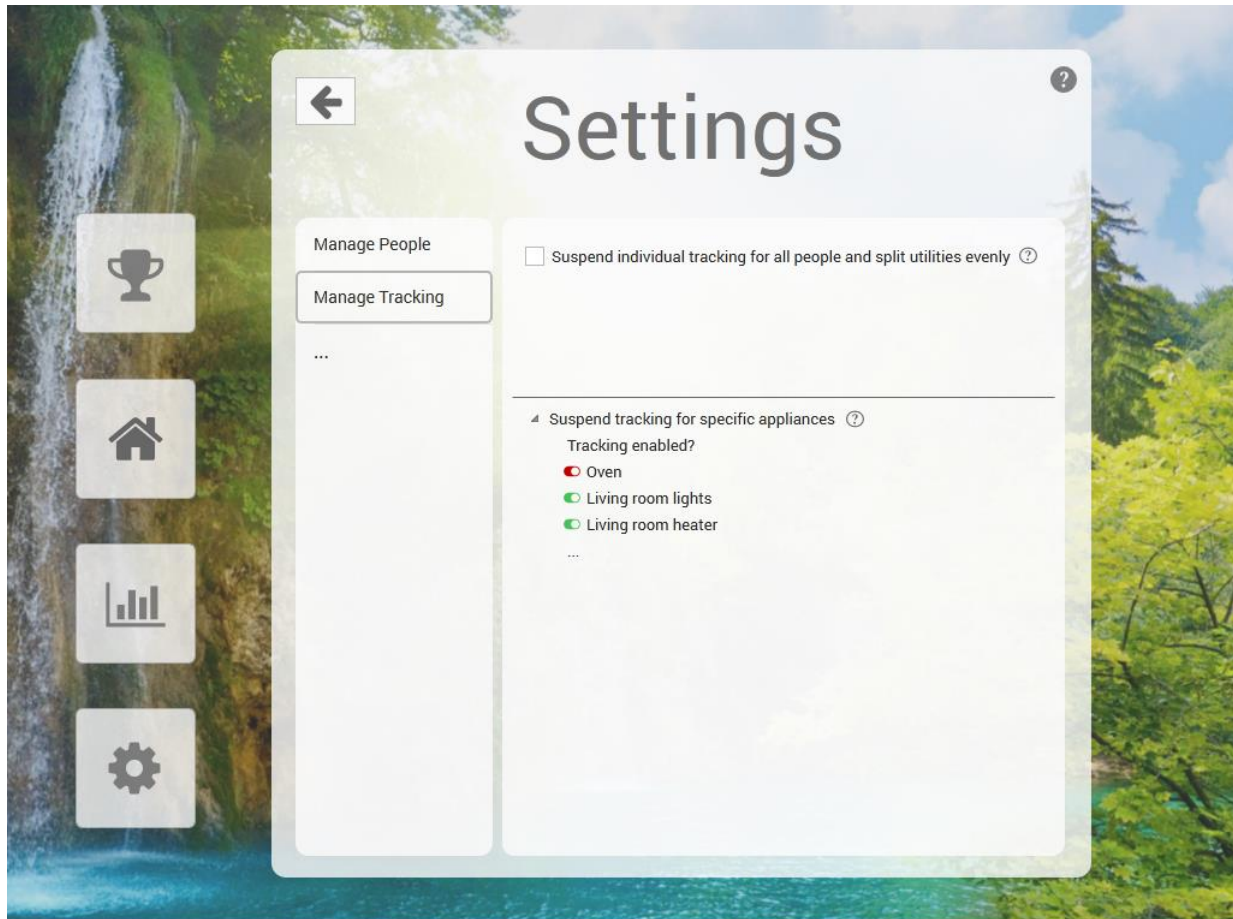
Discussion

As designers, we made a lot of assumptions about what was and was not intuitive and how people would interact with our design. We put certain functionality on certain screens because we thought they belonged there. We also did not always think about the minute details that makes good user interaction; for example, none of the screens on our initial paper prototype had "back" buttons. Iterating through critiques and usability testing quickly pinpointed flaws in our assumptions, and there were multiple points during testing where a participant made a comment and the team members looked at each other and asked, "Why didn't we think of that? It's so obvious." We learned that as designers, it is easy to be blind to flaws because we have spent so much time thinking about our design, and it is almost always better to test often and revise then to spend time making it "perfect." One of our mentors told us to "fail and fail fast," and we certainly found that was key to improving our

design. The big picture ideas that we learned and incorporated were: there should be more than one way to do something, consistency is key, observe and integrate participant intuition.

Our tasks started out more abstract than they should have been. They were great "task umbrellas" in theory: keep everyone accountable, understand your impact, pay what you use. What we didn't realize is that these encompass too much; for example, independent of design, does keeping people accountable mean that everyone knows what everyone else uses at any time? That you are able to answer the question "who left the light on?" Or that people have to make explicit actions to use utilities? These are questions we should have refined earlier. When we dove into usability tasks, we realize that tasks had to be grounded in a concrete end-to-end process, which was difficult because utility usage itself isn't a contained, conscious end-to-end process. We couldn't exactly ask people to "pay what you use." Reflecting on how we presented our tasks during the previous final report, we came back to the utility usage cycle: receive feedback, process feedback, take action based on feedback. We then prioritized and split our original tasks into two categories defined to be "gaining information" (understand your financial and environmental impact, compare your usage, keep everyone accountable) and then "taking action." Specific features were designed to support these main task categories, since we felt that explicitly choosing two smaller tasks would have limited the design. For purposes of usability testing and storyboarding, however, we focused on specific, concrete subtasks:

- **Understand why your previous bill was so high.** This focuses on processing feedback and then knowing what actions to take.
- **Turn off tracking for the oven.** One of our underlying goals was to use existing relationships to create motivation. We chose to make the assumption that "pay what you use" is enabled by smart technology - if we had tried to build the implementation of that into our design, it would have increased inconvenience in utility usage which was something that our contextual inquiry told us was paramount to avoiding if we wanted people to be more efficient. We thus thought, "Alright. People can use utilities like normal and they will be charged individually without requiring any extra effort. How do we now use that assumption and build motivation? What specific interactions could play out if people are charged for utilities on an individual basis?" We felt that turning off tracking for the oven (in context of one person cooking dinner for everyone else) was representative of other microprocesses that would make a "pay what you use" system successful in application.

In the beginning, we thought that if our tasks were abstract and broad, that would allow our design to naively solve as many things as possible. We quickly realized that for the scope of this class, refining tasks was crucial to success. If we could do this project again, we would have chosen concrete tasks from the beginning.

We probably could have used another iteration on our design after the digital mockup stage. Each iteration was very useful, with most of them resulting in significant changes. Both the heuristic evaluation and the first usability test were crucial in the development of our design. However, the second and third usability tests were not particularly useful except to confirm that the only issues with that prototype were fairly minor. Once we transitioned from the final prototype into the digital

mockup, we made a few changes that worked better with the design being digital, as well as overall improving consistency and making the design more minimal. Seeing the result of these changes through another test or critique could have been useful to further refine the digital mockup, so another iteration of the design would likely have been useful. That said, we are generally happy with our final design and feel like we improved on nearly all of the problems that made people have difficulty using it initially.

Appendix

UtilIQ Usability Testing Plan

Purpose
The purpose of our usability tests is to identify usability problems people have when they interact with our prototype.

Target Audience
Students or young professionals that live in shared housing with housemates they know.

Plan
1. Assign roles for each team member
2. Recruit people from target audience
3. Facilitator introduces our design to each of the participants
4. Have participant complete each of the three tasks
5. Debrief after test and make revisions to our design
6. Repeat steps 2-5 two more times

Tasks
1. You are Joe and you just got your bill for the month. It is extremely high and you are trying to eliminate some of your expenses. Figure out why your bill is so high and compare yourself to everyone else in the house.
2. You are about to cook dinner for all of your housemates so you should not be the only one charged for using the oven. Disable tracking temporarily for the oven.
3. Sally is leaving for the weekend and she does not deserve to be at the top of the leaderboard so disable tracking temporarily for Sally.

Materials/Equipment
- Laptops
- Pen and paper
- Notes for facilitator for important things to mention to participant as introduce our design

Study Script

Thank you for participating in our usability test. Before we begin, at any point if you feel uncomfortable you are free to leave. You are not the one being tested, we are testing the design. There is no right or wrong answer. Our goal is to learn how people interact with our design and find pain points in our design. We ask that you verbalize your thoughts throughout the test. This test will consist of three tasks we will ask you to complete.

UtilIQ helps people in shared housing that know their housemates track their utility usage to reduce their utility bills and save the environment. Our hub will be located in a communal area in the house. Let's begin.

Expected Results

The participant is given a task and may struggle initially as they familiarize themselves with design but they will eventually complete the given tasks.

What We'll Learn

The parts of our design that are not intuitive to use through critical incidents as participants complete their given tasks.

How We Will Measure Success

Speed to complete a task, participants thoughts as complete each task, and participants overall confusion level during and after each task process.
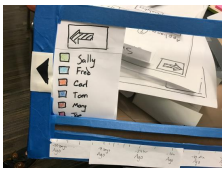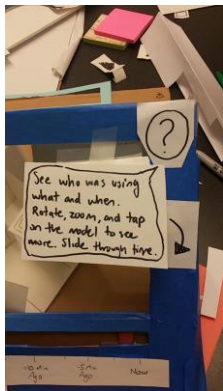
Follow-up Questions

How intuitive was the design to use?
What did you like and not like in our design?
If there is something you did not like what could we have done to make it easier to use?
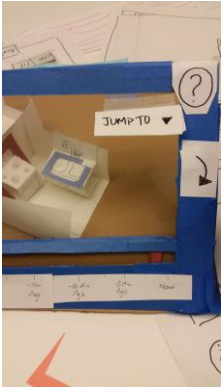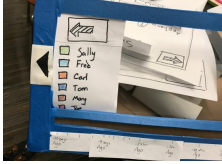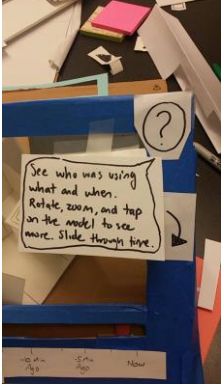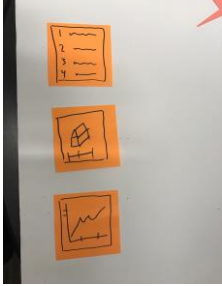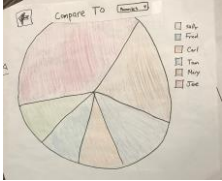
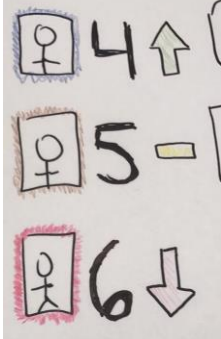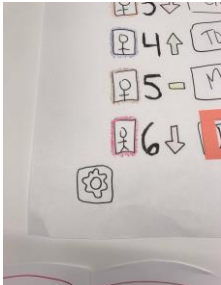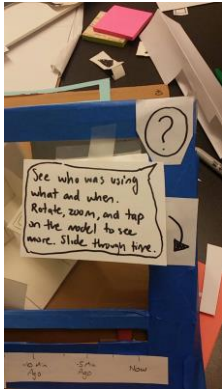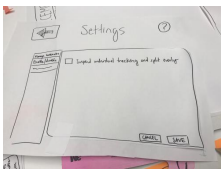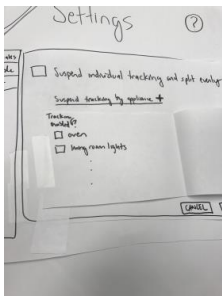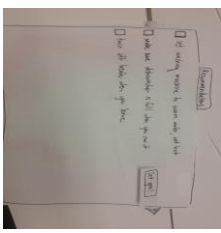## Full Results from Usability Test 1

Before Image	Description	Severity	Revision	Revision Image
	Was very confused by the house model at first, didn't understand what it did or how to interact with it	3	We added a help button to the house model page giving information on what is possible, consistent with the help buttons on other pages.	

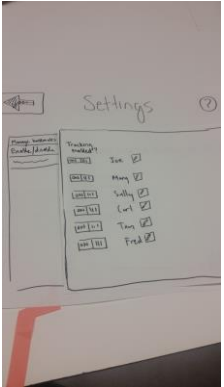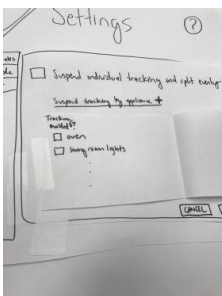|	Initially thought the colors on the house model meant if the device was on or off, but figured it out quickly without prompting	1	This was not a major problem, but the help button alleviates this issue.	
	Didn't know he could turn the house model until prompted	3	Changed arrow buttons to afford rotation	
	Didn't know he could tap on appliances in the model, never figured it out	4	This is fixed by adding a help button to the house model screen.	
	Knew the buttons on the home screen were the main navigation tools immediately	N/A	N/A	N/A
	Understood the graphs quickly and easily	N/A	N/A	N/A
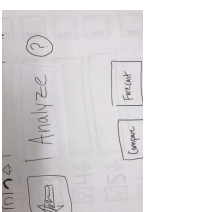
	Understood the arrows on the leaderboard meaning he was trending down	N/A	N/A	N/A
	When trying to disable tracking for the oven, looked first in settings, and couldn't ever find it.	4	This is fixed primarily by adding a help button to the house model page, and also by adding a list of appliances where each can be disabled (see below)	
	Expected there to be a list of all appliances somewhere	2	We added a list of appliances to the settings page where each can be disabled.	
	Was confused by the checkboxes in the recommendation tab	2	Replace the invisible "Set Goal" button with a greyed out/disabled button	

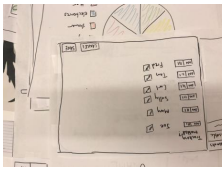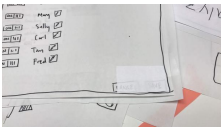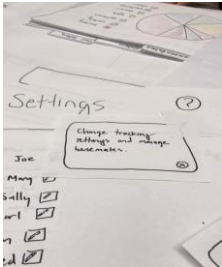|				
	When trying to disable tracking for Sally, went immediately to her profile	3	Added a disable tracking button to the profile	
	Did not see/understand the checkboxes at first, considered deleting Sally	3	Changed the Manage Housemates screen to make it more clear what the different functions did	
	Once he understood the house model basics, could navigate and understand it easily	N/A	N/A	N/A

Full Results from Usability Test 2
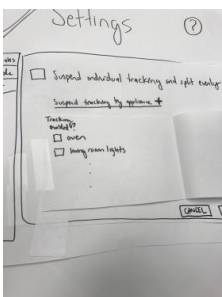
	Quickly knew that the orange buttons were for navigation	N/A	N/A	N/A

	Was slightly confused by the wording regarding tracking.	1	When you expand it, the wording is clarified, so it is not a significant issue and we decided not to change it.	
	Knew to go to settings to disable tracking for individual appliances.	N/A	N/A	N/A
	Was confused by the title on the Analyze transitional window because it is boxed and looks like a button.	2	We changed it to being underlined rather than boxed so it no longer looks like a button.	
	Immediately went to settings to check for disabling tracking.	N/A	N/A	N/A

	Was very impressed by the slider on the house model to let him view across time.	N/A	N/A	N/A

Full Results from Usability Test 3

	Immediately knew that the names on the leaderboard were clickable, and went there to learn about his usage.	N/A	N/A	N/A
	Thought the "cancel" and "save" buttons combined with the confirmation dialogs in the settings were confusing.	2	We removed the "cancel" and "save" buttons, and now changes happen immediately.	
	Clicked the help button on the settings page when he wasn't sure what different things did, and after doing so he understood.	N/A	N/A	N/A
	Was able to find the disabling tracking in the settings very quickly.	N/A	N/A	N/A