Eco Touch

FINAL DELIVERABLE

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Introduction

Executive Summary

This report details the process of creating Eco Touch, a touch table game concept that educates players on sustainable practices in homes. It is designed to be an exhibit at the Stony Brook Millsone Watershed Assocation in central New Jersey. The idea of Eco Touch stemmed from Human-Computer Interaction (HCI) research methods, iterative design and numerous rounds of user testing conducted by five HCI students from Carnegie Mellon University.

HUNT STATEMENT

> “Create an exhibit visualizing and encouraging sustainable building practices through simulated environmental data to foster an educational environment for center visitors.

The Watershed

The Stony Brook Millstone Watershed Association is constructing a new environmental center, which will integrate an array of sustainability features as part of its pursuit of LEED Platinum status, with net-zero energy consumption. For more than 60 years the organization has worked to protect central New Jersey’s water and environment through conservation, advocacy, science, and education. The new center will incorporate exhibits, classrooms, and a laboratory that focus on helping people to understand environmental issues and take the proper steps for a better future. The center’s many green systems, which include geothermal HVAC, diurnal ducting, wetlands-based wastewater treatment, a green roof, solar arrays, and more, will all serve to reduce the impact the center has on the environment. However, to fully achieve their mission statement, the association seeks to install an interactive exhibit that simulates data and educates visitors on sustainable building practices.

Our goal for this project is to design an exhibit that can appeal to children, homeowners, contractors/building officials, and policy makers to enhance their understanding of sustainable systems and encourage environmental sustainability in specific real-world contexts.

Research

Overview

We visited three museums, one analogous environmental center and utilized 8 research methodologies to organize our observations. This section will further explain what each method is and how we applied them.

FLY ON THE WALL

Fly On The Wall: *Observation method that allows researchers to passively study a situation / behavior without interrupting the flow of the subject and the environment.*

In order to gain a basic understanding of how individuals interact with museum exhibits, we spent several hours in a few museums noting the interactions and movements of individuals. We spent approximately 30 minutes in each of the exhibit spaces recording notable interactions and break-downs that users had with each particular exhibit. In order to capture the largest number of interactions, we split up into two teams and rotated between the different museums.

Carnegie Natural History Museum

As part of our initial research we chose to visit the Natural History Museum, which has a variety of interactive exhibits. We observed how visitors engage with these displays, which ranged from primarily informative to highly immersive. We noted what features seemed most effective at drawing visitors in and holding their attention. We also focused on the types of visitor behavior, and took into consideration how the museum promotes (or does not promote) learning and excitement through different mediums.

Children's Museum of Pittsburgh

Children's Museum of Pittsburgh provides the team opportunities to study young children and their parents' behaviors in museums. At the Children's Museum of Pittsburgh, the team spent approximately three hours in total observing the interaction between visitors and exhibits. We noted features that succeeded or failed in attracting children and adult visitors, keeping visitors engaged and encouraging cooperation between visitors. The team also followed several families and quietly took note, trying not to intrude on the interaction patterns that naturally emerged between children and parents.

Carnegie Science Museum

Due to the broad age appeal of the Carnegie Science Museum, we decided this would be an excellent place to find exhibits that work well for both adults and children. Additionally, since the exhibit we will be designing is focused on environmental science, we recorded which interactions worked well to convey scientific concepts to individuals.

ANALOGOUS DOMAIN

Center for Sustainable Landscapes (CSL)

Since the Watershed Association's environmental center is not yet complete, we used analogous domain to do some observation. The team went on a private tour of the CSL at the Phipps Conservatory to learn about sustainable practices and study the interactions within the domain. The CSL has many similarities to the Watershed Association environmental center. It is LEED certified and has similar sustainable systems in place such as geothermal heating, a green roof, a water treatment system, and rainwater harvesting.

WRITE YOUR EXPERIENCE

Write Your Experience: *Method to study visitors' post-exhibit impressions. Visitors were asked about their experience while interacting with the exhibit and through drawing or writing, they demonstrated information they took away.*

In order to obtain a better understanding on how people interact with and learn from exhibits, we had individuals at the Carnegie Natural History Museum answer a simple question: "Can you tell us a piece of information you learned from the exhibit you just walked through?". Individuals were given with a piece of paper, and were instructed to either write or draw something that they learned from the exhibit they walked through. Additionally, we noted the particular type of user we were talking to, and who they were traveling through the exhibit with. Then, taking into account the features of the individual, we analyzed the responses given to us, tracking down where they gleamed the information from and recording particular features of that exhibit and how it presents information. This allowed us to determine what features of the exhibit were appealing to each user group.

AEIOU

AEIOU: *A heuristic to help interpret observations gathered by ethnographic practice in industry. Stands for Activity, Environment, Interaction, Object and User.*

We used the AEIOU heuristic to consolidate the observation notes we gathered from the trips to the museums. From our notes, we extracted vignettes of the museum experience using AEIOU, focusing on revealing the interactions between these five elements. (For more information regarding this method, please visit: http://help.ethnohub.com/guide/aeiou-framework)

HEURISTIC EVALUATION

Heuristic Evaluation: *An inspection on a piece of software for usability concerns in its interface design.*

At the CSL, we noticed a kiosk by the entrance and performed a heuristic evaluation on the software. The software provided information about each sustainable system in the building and graphical representations of live numeric data pulled from each system. We used Nielsen's 10 heuristics as the baseline for our evaluation.

INTERVIEW

The team had the pleasure to interview five different individuals who each take an active role in the environmental education realm. Our first interviewee was a master student at Carnegie Mellon University studying Sustainability Design. Our second interviewee was a grade -school teacher at an environmental charter school in Pittsburgh. Our third interviewee was the Environmental Program Coordinator at Carnegie Mellon's Steinbrenner Institute of Environmental Education & Study. Our fourth interviewee was the Director of Learning Research at Carnegie Museum of Natural History. Finally, our last interviewee was a tour guide at the CSL.

MARKET ANALYSIS

Market Analysis: *An assessment of the strengths and weaknesses of existing products in the market.*

We conducted a market analysis to help uncover what features of existing museum exhibits elicit positive responses from users. Our focus centered exclusively on interactive exhibits that incorporate technology -- that is, exhibits with some digital aspect that require input from the user to generate a desired output. After thorough investigation, we rated each exhibit in the following categories: aesthetics, usability, audience appeal, and instructional ability.

LITERATURE REVIEW

Aside from doing observations and interviews, we looked at several academic papers related to exhibit design and visitor interactions. The first article was about the importance of collaboration and the environment that shape an exhibit. The second article was about how a visitor's mindset helps immerse them in the exhibit experience. The third article described the elements in an exhibit and the demographics each element attracts. The fourth article detailed how effective an open-ended exhibit and a novel exhibit and increase visitors' attention span. Finally, the last article explained an experiement done on users to figure out what kind of learning experience museum visitors prefer.

Findings

After extensive user research, we developed the framework below to help us understand the typical interaction a visitor has with a museum exhibit called the “Exhibit Journey Model”. It begins with surprise, the proverbial “hook” that draws a visitor toward the exhibit in the first place. Next, it is incumbent on the exhibit to keep the visitor engaged, and to keep the interaction going. Simultaneously, the hope is that while the visitor is engaged with the exhibit they are actively absorbing and learning information in line with that exhibit’s instructional goals. Finally, and arguably most importantly, the desire that users will take the knowledge with them and apply it in to their life outside the museum. We now explore our research findings and their place in this overarching framework.

ANALOGOUS DOMAIN

For our trip to the CSL, we put ourselves in the shoes of first-time visitors since we knew very little about sustainability practices thusfar. From the tour, we learned in detail about energy-saving initiatives and water treatments at the center, and were able to witness some of the building’s green features in practice. Our guide was very informative and was also able to explain the criteria for LEED certification and the Living Building Challenge. Most of the visitors at the center are engineers or business individuals looking to dissolve energy-saving knowledge and green building construction methodologies. When the weather is nicer, they do occasionally get younger visitors such as college students and sometimes even younger children with their parents.

WRITE YOUR EXPERIENCE

During our second trip to the Natural History Museum, we conducted a Write Your Experience study with museum visitors. From this study, we learned that children and adults alike do not pay much attention to the text by the exhibits. They generally search for pictures and visually engaging elements such as animations and the exhibit’s responses to touch or physical movements. Parents also determine the value of a museum trip primarily based on their children’s experience, which is important to note as it provides insight to our design demographics.

HEURISTIC EVALUATION

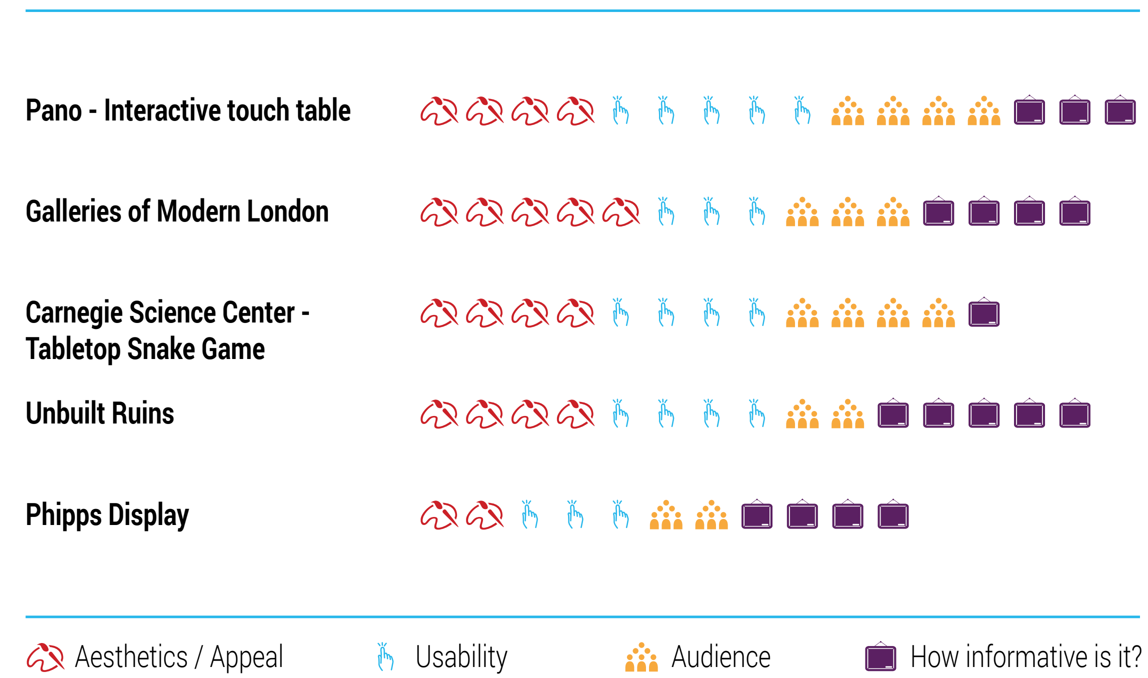
At the most basic level, the exhibit that our client is expecting us to design is an interactive display mounted on a wall. During our trip to CSL, we did a heuristic evaluation on their touch screen display as it serves a similar purpose. We noticed from the evaluation that some parts of the software animations were very eye-catching. The interactive floor plan of the building was also helpful in that visitors can picture the area as they learn about its environmental efforts from the display. Nonetheless, we did realize that the descriptions on the display were extremely cluttered at times and it is unlikely that people would actually read the text. This could be partially fixed if the screen were larger. Lastly, when a family with little kids walked by the display, we saw the their children could not physically reach the display.

MARKET ANALYSIS

As mentioned in the previous section, we used the following categories for review: aesthetics, usability, audience appeal, and instructional ability. We gathered instances of exhibits from a combination of online research and those we’ve seen in person by visiting various museums throughout Pittsburgh. Our focus was to discover the delicate balance that exists between drawing users in, keeping them engaged, and informing through a simple interaction.

The biggest and most obvious insight that can be gleaned from our data is that it is very difficult for exhibits to thrive in all four categories. While some of the exhibits we researched have high aggregate scores, most of them did not have average scores higher than a 3.5. Oftentimes, as in the cases of Pano, the Tabletop Snake Game, and the Phipps display, there is an inverse correlation between aesthetics and informative ability. It appears difficult to immediately grab an audience's attention while also serving some instructional purpose. Similarly, those exhibits that excel at teaching visitors something, do so at the expense of being accessible to all audiences. For example, the Unbuilt Ruins exhibit is one of the few with both high aesthetic value and high instructional value. However, it seems to have accomplished the latter by limiting its focus to adults and being virtually inaccessible to younger audiences.

The implication here is that it is immensely difficult for an exhibit to be all things to all people. That is, we must prioritize the categories that matter to us most and focus on making our exhibit thrive, while accounting for the other categories that may suffer. That being said, if we recognize that for whatever reason the practical applications of the four aspects that we defined are inversely proportional, then we can make a concerted effort to fortify those weaker categories and thus minimize their weaknesses.



LITERATURE REVIEW

"Exhibiting Interaction: Conduct and Collaboration in Museums and Galleries."

The article, *Exhibiting Interaction: Conduct and Collaboration in Museums and Galleries* illustrates the importance of the way a person is introduced to an exhibit, and how their companion(s) or other visitors of the exhibit affect the experience they have. The authors mentioned several scenarios captured on camera that indicate factors -- such as time spent at the exhibit, what the visitor takes away, how to interact with the object or device -- which are heavily dependent on the environment and how the public space is shared. In one particular example, when a couple approached an interactive puzzle station, the man encouraged the woman to work on the puzzle together verbally but his body language suggested otherwise. He stepped in front of the woman and took up the physical space at the station that was the most easily accessible to her. From this article, we learned that despite how well designed our actual exhibit is, we also have to beware of how the system is handled and interacted with on-site. People's user experience heavily relies on the set up prior to the interaction with the exhibit and also how it is facilitated during interaction.

"The Influence of Museum Exhibit Design on Immersion and Psychological Flow."

The Influence of Museum Exhibit Design on Immersion and Psychological Flow studies the concept of psychological flow and how museum exhibits can have a high flow level. Psychological flow occurs when an individual's goal is the experience or behavior itself rather than a future reward or advantage. In the case of exhibits, this happens when an individual is found to be immersed in the experience of the exhibit, rather than just reading the information for future use. The paper explores this in two context: the renovation of a museum exhibit, and the particular features of different exhibits within the same museum. Overall, it was found that three features - interactive components, multisensory stimulation, and dynamic displays - where the most salient and important to visitors.

"Learning from interactive museum installations about interaction design for public settings."

This paper reports on the evaluation of a digitally-augmented exhibition on the history of modern media. The authors adopted a multi-method strategy, drawing on results from analysis of log files, interviews, and observation in the museum. As a case study on what makes a public museum installation engaging, this paper provides useful recommendations on the choices of interfaces for different demographics. The authors find that that younger visitors are drawn to computational media while older visitors interact more with historic objects. Only the interactive hands-on exhibits succeed in engaging all kinds of visitors. Besides the age effect, the paper also suggests that most visitors are overwhelmed with too much text and would only try exhibits with a low threshold for interaction.

"Technological Novelty and Open-Endedness: Two Characteristics of Interactive Exhibits That Contribute to the Holding of Visitor Attention in a Science Museum."

The article investigates several factors utilized by interactive exhibits in order to hold visitor attention. The authors refer to previous studies on attention and cite the success of exhibits that are large, concrete, moving, and sound-driven. In their own study, the researchers track 47 visitors through 61 exhibits and measure the attracting power and average holding time of different exhibits. Four characteristics are identified as being most effective: technological novelty, user-centeredness, sensory stimulation, and open-endedness. The article proposes that studying these categories might contribute to science educators' understanding of visitor behavior, visitor learning, and visitor interactions at these exhibits. Using regression analysis, the study finds that two characteristics, technological novelty and open-endedness, help account for a significant portion of the variance in average holding time. The paper defines a technologically novel exhibit as possessing at least one of the following criteria: 1) The exhibit contains visible state-of-the-art devices. 2) The exhibit, through the use of technology, illustrates phenomena that would otherwise be impossible or laborious for visitors to explore on their own. An exhibit is defined as open ended if it meets one of the following criteria: 1) The exhibit allows for the achievement of multiple visitor-set goals. 2) The exhibit allows for one goal to be achieved in multiple ways.

"Technologies and Methods for Interactive Exhibit Design: From Wireless Object & Body Tracking to Wearable Computers."

This article explores methods that utilize technology to help engage and inform museum-goers. It claims that users who are given a more customized, dynamic experience tend to be more satisfied with their museum visit. The two methods it explores are custom information overlay, and smart clothes. Custom information overlay is driven by sensors placed at specific exhibits which modifies the visitor's experience based on their input. Smart clothes are affixed to the visitor and are manifested in the form of wearable computers. Technologies of this type afford the user an augmented experience which allows them to absorb the exhibits on their own terms. These two primary ideas are then explored through three projects the researchers put into place.

Insights

Following our data consolidation, we compiled a list of 10 major takeaways derived from the research methods we used. The Exhibit Journey Model is embedded in these takeaways to help us visualize and organize these lessons for the design phase.

SURPRISE

1. Multisensory

Exhibits that appeal to multiple senses engage visitors for a much longer period than exhibits that just appeal to a singular sense. In the Harvey, Loomis, Bell and Marino paper, the having a multisensory component was one of the top 3 salient features in their model of exhibit immersion. Additionally, during our observations at the Children's museum, exhibits that featured a sound and light component in addition to a touch component attracted more visitor attention, especially from children.

2. Exhibits need to afford their interactions.

The interactions that are available to a visitor must be made apparent through the exhibits design. While the interactions of other visitors with an exhibit can often help transfer the knowledge of available interactions, ideally an exhibit should be approachable on its own with little to no additional instruction. If some instruction is required, the instructions should be part of the exhibit experience, rather than a separate note attached to the exhibit. The Monstroscopy and Stars and Moon exhibit at the Children's museum both featured non-obvious interactions, with separate instructions that often did not translate well to passing visitors.

ENGAGE

3. Minimize the amount of reading users have to do.

Museum visitors, generally, do not want to have to read a large amount of information. While there are those individuals in museums who enjoy moving from exhibit to exhibit, reading every piece of information there, most visitors, especially kids/teens, are not interested in having to read a lot of information. This was noted during our "Write your experience" method; most visitors did not report on any information they read about from the exhibit, but rather an interesting interaction they had with a particular exhibit, and any information they happened to learn from it.

4. Collaboration is king.

When visitors are encouraged to collaborate, they glean more from the exhibit and stay engaged for a longer time. In our literature review, for example, we have seen that there are two specific instances when collaboration is essential for a good experience: 1) when a visitor gets called over by another visitor and engages with an exhibit when they otherwise would not, and 2) when a visitor sees another visitor have a positive experience with an exhibit and voluntarily joins in. In our discussion with an environmental literacy teacher, when asked about collaboration between her students she said, "Unless it is a graded assignment when I really want them to be thinking about things independently, I do have them work together because I think they learn more from each other. I think they also stay involved with the task longer".

5. Consider how physical constraints limit audience

Museum exhibits should be accessible to all visitors. The heuristic evaluation at the Center for Sustainable Landscapes supports this claim. If a display is far too high for children to reach, they will not want to wait around and as a result, parents will be pulled away. Similarly according to the affinity diagram, adults did not notice the presence of certain screen displays either because the screens were not placed at the proper height for visitors to see them or that the display was not placed right next the actual exhibit for visitors to make that connection between physical and tangible parts.

6. Open-ended exhibits hold visitors’ attention longer.

Exhibits that are open ended hold visitor attention better and enhance the learning process. From the Sandifer article, we learned about the importance of exhibits that allow for the achievement of multiple visitor-set goals and allow for such goals to be achieved in multiple ways. For instance, part of the success of the laser exhibit at the Science Center comes from the fact that there is no wrong way to do things, and visitors can try out different approaches. Our interview with a teacher also revealed that having kids figure things out for themselves is a critical learning technique.

> “Kids have the ability to manipulate things themselves. They are still at the stage where creativity should be encouraged.
>
> *Charter school teacher*

7. Engage passive users.

From the literature review, we learned that the environment an exhibit is in shapes the experience of its visitors and can affect whether or not the visitor approaches the exhibit. This demonstrates the importance of ‘charming’ a passive visitor as it can transform a passive visitor to an active one. From the affinity, a father was pulled over by his children to interact with a robot. Although the father was not initially engaged with the robot, he was convinced by others around him. Similarly, having museum staff help engage passive visitors also help enhance visitors’ experience and encourage them to try out more features of the exhibit.

8. Proactive staff help to encourage interactions with and maintain exhibits.

Museum staff act in a variety of roles, from cleaning up exhibits, to encouraging interaction, to troubleshooting exhibits. The staff are essential in making sure exhibits work and understood by users. While visiting the Carnegie Science Center and Children’s museum, we noted that staff regularly cleaned up the messy activities that kids participated in, as well as relating exhibits back to a local context. Our tour at the CSL was essential to our understanding of the building features; without the staff interaction in that case, we would have missed several non-obvious features of the building.

LEARN

9. Parents are at museums for their kids.

When parents take their children to a museum, their focus is not on their own experience, but rather on their children’s experience. From our visits to the Carnegie Science center and Children’s museum, it was noted that children are often seen leading their parents around. Additionally, during our “Write your experience” visit to the Carnegie Natural History museum, individuals there with children frequently wrote what their child enjoyed/remembered in the exhibit, rather than any takeaways that they had.

10. Strengthen the tie between the physical and digital.

While our research has shown that it is of great benefit to include both tangible and digital components in a museum exhibit, it actually serves as a detriment if the tie between the two is not strong. For example, in the Children’s Museum there is an exhibit in which visitors would “complete a circuit” with their hands, and it would manipulate things on a screen. The problem arose because the screen was approximately 10 feet away and there was no indication on the physical device that their input was doing anything. So kids would touch the circuit, not get any feedback because they couldn’t see the screen, and leave in frustration.

APPLY

The final step of our exhibit visit model extends beyond the visit of the museum. From our observations at the museums and our interviews with active members in environmental preservation realm, it was unclear what exactly visitors did with the knowledge or experiences they acquired after their museum trip. To fully achieve our hunt statement, we need to ensure that our exhibit visitors take away some information and act on it. Examples of this include: sharing their exhibit experience with family and peers, doing more research online, or even designing a building layout with a sustainable building practice in mind. In our next design process, we plan to incorporate this idea into our prototype.

Conclusion

From our research, we discovered numerous factors that influence a visitor's museum journey from start to finish. The critical points to consider in this journey are the surprise or the event trigger, the interaction and knowledge acquired from the interaction and finally the transfer of such knowledge beyond the exhibit tour. In order to achieve this, we should create a novel and/or well-guided experience, facilitate collaboration between visitors, cater to the physical constraints of a visitor, understand what is important to the visitor and provide a memorable experience that one can apply in context of the real world.

Design Concept

User Types

Persona: *Fictional people of the target user group created to help designers shape their design direction*

With our framework of Surprise, Engage, Learn, and Apply in mind, we created several personas, applying each one to this model. We also considered what the goals of a *lawyer*, *teacher*, *university student*, *high school student*, *commercial contractor*, and *city councilwoman* would be when visiting an environmental center. We found it helpful to think about the different ways that these types of users could be attracted to an exhibit. Once they had been drawn in, we looked at what aspects of an exhibit would hold their attention. Next, we wanted to know what specific knowledge that users would seek, and how learning might be accomplished. Finally we addressed various ways to give them something to take away from their experience.

High School Teacher

Name: Noel Simon
Occupation: Teacher
Interests: Horseback riding, Landscape painting

Scenario: Mrs. Simon teaches 7th grade Earth Science at a public school in Linden, NJ. She tries to keep her students excited about learning by taking them on field trips and having them participate in hands on experiments. Mrs. Simon is an outspoken advocate of recycling in her community, and recently she and Mr. Simon installed rain barrels in their backyard.

Goals:

- Go through exhibit and explain what is going on to her students.
- Take away some new information about sustainability practices and apply it in her class

Surprise:

- Students dragging her over
- Motion graphics / Some sort of screen saver mode
- Sound
- Staff encouragement

Engage:

- Nicely presented documents with graphics / animations
- "Additional resources for teachers"

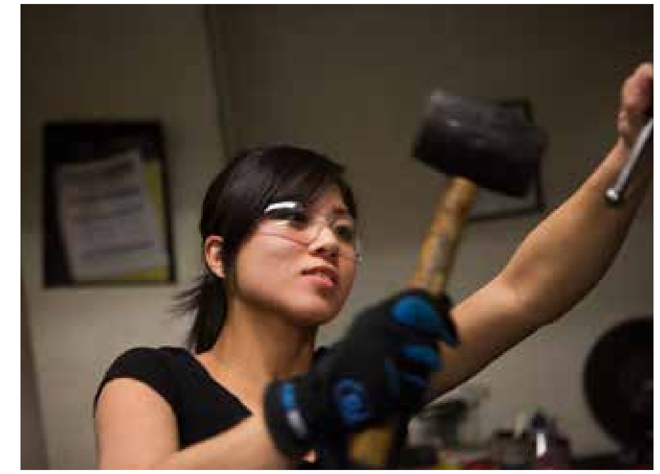
Learn:

- Ideas for class projects
- Look at what other students/teachers have done in the past at the camps

Apply:

- Take some ideas from the exhibit and apply it in their curriculum

Civil Engineering Student



Name: Polly Sidon
Occupation: Student
Interests: Frisbee, Grey-water treatment

Scenario: Polly is doing research for a class project involving sustainable building methods. She knows that the Stony Brook Millstone watershed association has a new LEED Platinum certified building. She decides to visit the building to learn more.

Goals:

- Learn about what building features are cost effective / make an impact
- How to apply/implement the features

Surprise:

- Interesting building model, appropriate signage (she has a goal in mind)
- Novel tech -- college students that likes

Engage:

- Technical information
- Connection back to the real technology

Learn:

- Cost effectiveness of each technology
- How ubiquitous the different technologies are

Apply:

- Take technologies and incorporate them into her current and future projects.

Building Contractor

Name: Jack Smith
Occupation: Commercial Contractor
Interests: Football, Beer

Scenario: Jack has been working for ExoBuild for the past 7 years. Exobuild has been designing buildings since the 60s, and is just starting to get into building LEED certified buildings. Jack, being one of the youngest people in the office, is trying to find out which building methods are the most common and cost efficient.

Goals:
- Try to become familiar with various environmental practices so that he can do further research on his own

Surprise:
- Hands-on exhibit with building model may be relatable to his field
- Staff guidance

Engage:
- A "How to use this in your life" section
- A model of the cost/effectiveness of the different practices
- Comparison of buildings outfitted with different practices

Learn:
- Self-discovery of potential best practices based on cost and effectiveness
- Outlets for further research
- Discussion with staff/ other contractors about the different practices

Apply:
- Discover what building practices work best in different situations

Policy Maker

Name: Jean Blau
Occupation: City Councilwoman
Interests: Farmer's markets, Gardening

Scenario: Jean just recently heard a proposal that encourages new buildings to be LEED certified. She doesn't know a lot about the benefits and requirements of a LEED certification, so she wants to explore nearby buildings and exhibits.

Goals:
- Find out what is relevant in order to make informed decisions regarding the city's environmental agenda

Surprise
- Guidance from another member in the environmental center
- Multisensory (flashing lights, sounds)

Engage
- Pop-up information
- Animations / visual aesthetics
- Game logic

Learn
- Information about sustainable systems applicable to a typical household (eg. tax credits received from geothermal well)
- Information about what the general public wants

Apply
- Create a new environmental agenda to incentivize local households t acquire environmental systems

Mom with 8-year Old Child

Name: Mary Cobblestone
Occupation: Lawyer
Interests: Reading, Scrapbooking

Scenario: Mary is in her early 30s. She went to college in UVA and she now works for a large law firm in DC. She lives with her husband Dave and her 8-year-old daughter Lana. Mary isn't really enthusiastic about learning new things because her work keeps her busy for most of the time. But the family enjoys visiting museums on weekends to spend time together.

Goals:

- **Wants to go to the museum to relax and entertain her daughter**
- **Likes to understand the main point of an exhibit, without having to go through tedious details**

Surprise

- **Anything her daughter runs to (on a similar note, anything her daughter doesn't like is detrimental to the exhibit's attraction)**
- **Multisensory**

Engage

- **Animations with colors that move**
- **Physical objects/toys - anything that the daughter would like**
- **Can't be a long interaction since mom has to cater to kids**

Learn

- **Household/family relevant facts**

Apply

- **Think of possible systems to install in their home while teaching her daughter about sustainable systems and how they benefit the environmental and the family**

Ideation Process

INDEPENDENT IDEATION

We began brainstorming with an independent idea generation process. We sat in a room and came up with as many exhibit ideas as possible in 15 minutes. There were no restrictions on scope, cost, or absurdity. At the conclusion of our time, we had a total of 40 concepts ranging from the very practical informational wall display to the slightly-less-conventional sculpture to simulate the water process through the movement of metal balls. These ideas were then used to prompt the consolidation process discussed next.

CONCEPT CONSOLIDATION

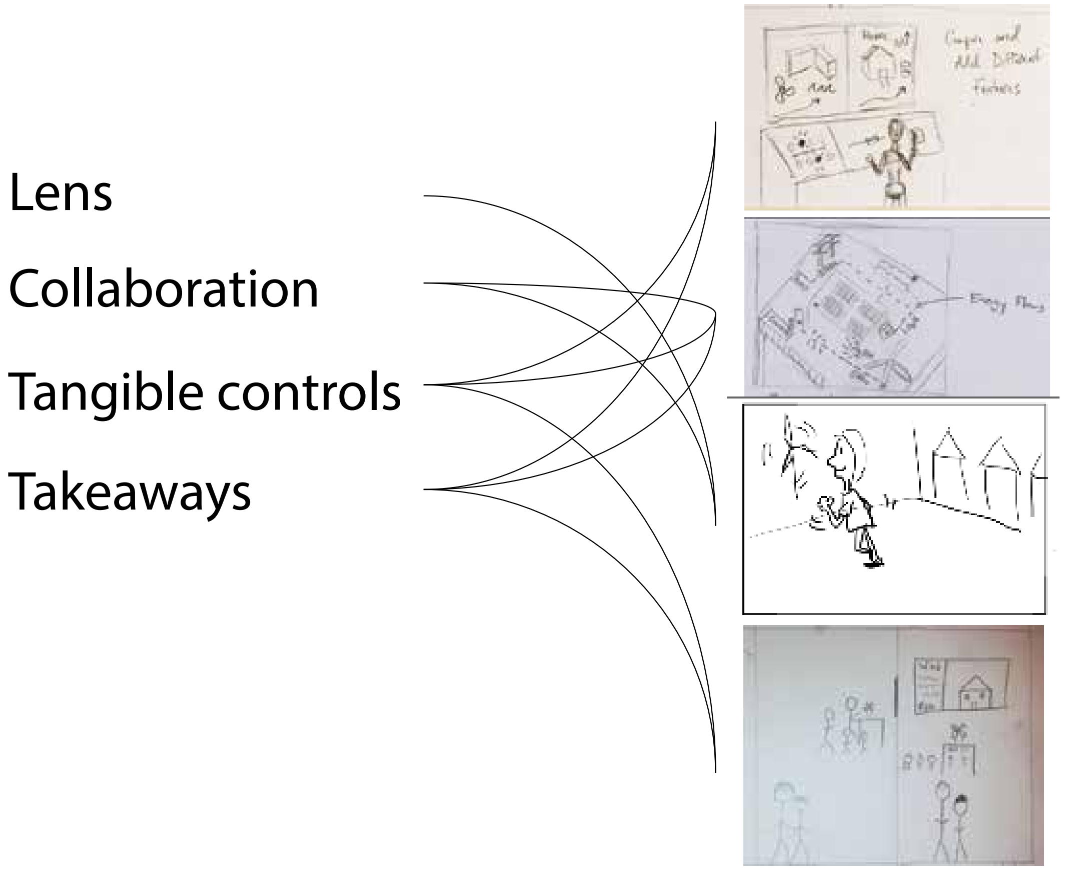
Affinity Diagram

Affinity Diagram: *A method of categorizing data and ideas generated from research.*

After individually generating ideas, we grouped them into an affinity diagram to identify common themes that we had. The themes we identified from this process were *games*, *building a community*, *highlighting individual systems*, *cost benefit analysis*, *things to take home*, *embeded experience tour*, *analyzing a building*, and *creating a building with pieces*.

FEATURE EXTRACTION

After performing an initial grouping, we then identified key features among the groups by looking at common characteristics of each theme. These were *lens*, *collaboration*, *tangible controls* and *takeaways*. 'Lens' refers to the ability to zoom in and out of certain exhibit aspects to explore its content in different levels of detail. Collaboration refers to the ability for visitors to work together and discuss their experience at the exhibit. Tangible controls will help prolong visitors' excitement when engaging with some physical aspects. Lastly, we want visitors to have



something to keep with them as a reminder of their experience with us. We then took these features, and used them as our goals for the storyboarding process.

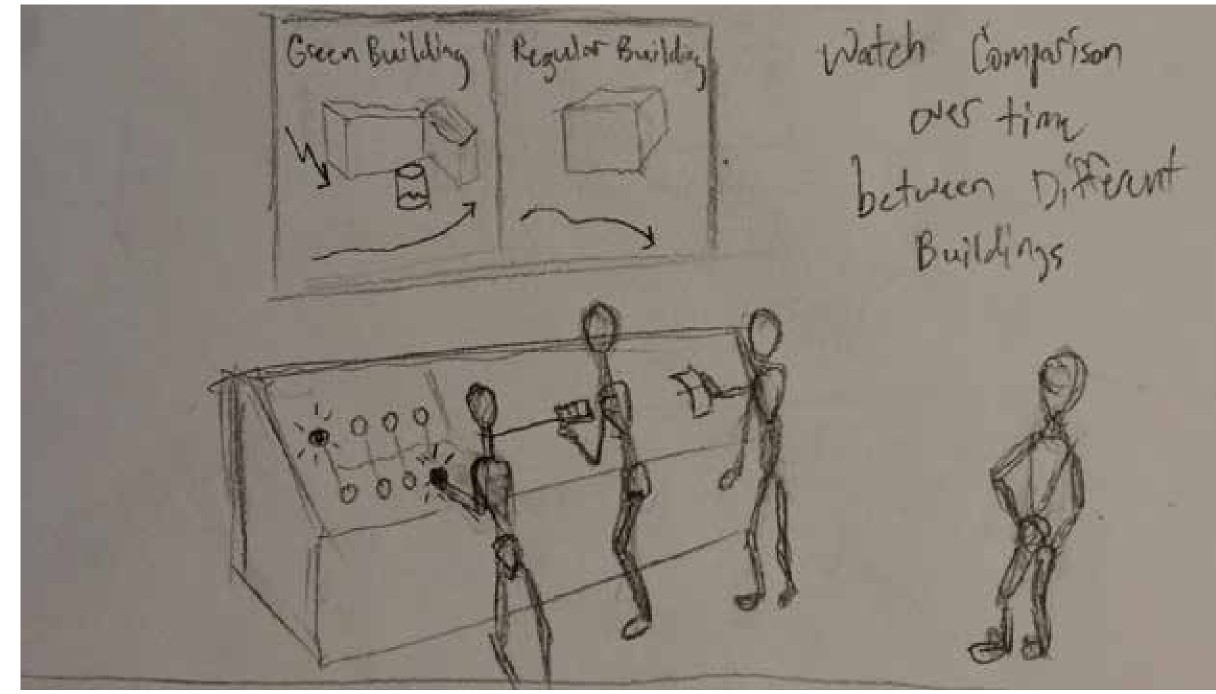
STORYBOARDING

Storyboard: *Illustrations of images used to demonstrate a concept and how it is perceived by potential users.*

We came up with a total of five storyboards, each trying to encompass at least two features from the feature extraction.

Storyboard 1: Control Panel Comparison

This storyboard highlights the comparison between regular buildings and green buildings. A wall-mounted screen would display a green building and a regular building side by side and visualize the energy generation / consumption of the buildings. A control panel with physical knobs would be installed below the screen. Visitors could tweak the knobs to adjust the settings of the green systems or add features to either of the buildings. They can then directly observe the impact of their adjustment through the change of the simulation on the screen. In its ambient state when nobody is using the control panel, the screen would display live data of the building.



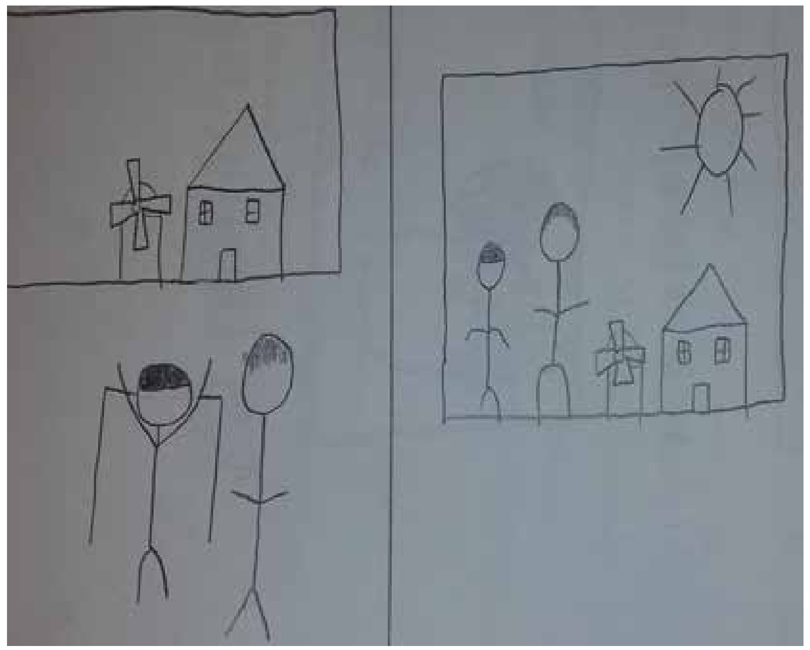
Storyboard 2: Energy Flow Model

In this concept, physical models of different energy saving systems are connected to a house model, all placed on top of a touchscreen table. The table would show how each green feature is contributing to the building's water and electricity systems by visualizing the energy flows between systems. Additionally, users can start a simulation by picking a location and a budget for the house. In simulation

mode, the display would change to incorporate the area and the features would scale to fit the budget, and users are challenged to achieve the minimum energy consumption by adjusting aspects of the green features.

Storyboard 3: Interactive Projection

Here, visitors use their body movements to interact with a projection of the panorama of the environmental center. The green systems in the projection would react to people's movement by generating energy that flows into the image of the environmental center. The amount of energy generated would correlate to visitors' amount of movement.



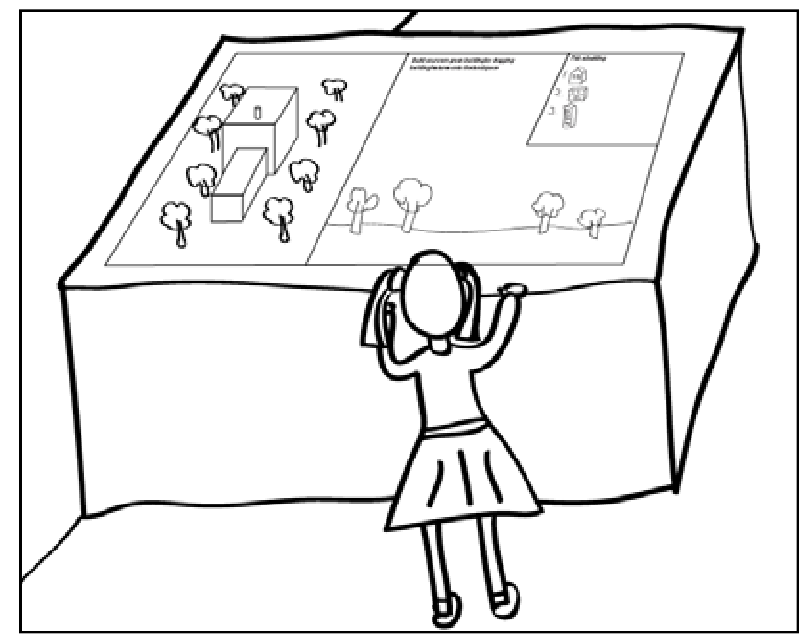
Storyboard 4: Pedestal Display

Here, visitors can build mini house models by placing building blocks onto a pedestal. Each building block represents a certain energy saving system or a structure made in particular green material. When a block is placed on the pedestal, a wall mounted display next to the pedestal would show detailed

information about the embodied feature, analyzing the cost and benefits the it brings. From there people can decide weather or not to incorporate the feature into their houses. Ultimately, visitors can take photos with their house models before they leave.

Storyboard 5: Comparison Model

This storyboard also tasks visitors to build a green building using given energy saving features by providing a physical model as a reference. A physical model of the environmental center would be placed side by side with a touchscreen table where users' customized building is displayed. Users can drag features they learned about in the physical model into their virtual building.



SPEED DATING & CONCEPT REFINEMENT

Speed Dating: *A series of concept-sharing with other individuals to acquire feedback and validation from a third-person perspective.*

To quickly receive feedbacks on the five storyboards we created, we did Speed Dating with the Phipps Conservatory Soundscape team. Their project involves a similar domain as ours, and we felt that their knowledge of museums and environmental practices could provide us with useful insights. The speed dating session went on for one and a half hours, during which we presented storyboards one after another to the team, took notes of their comments and exchanged ideas.

After testing our storyboards through the Speed Dating process, we determined that many of our design ideas delivered similar content, but in vastly different ways. Our Speed Dating subjects responded well to designs that involved the movement of physical objects/controls, had ways to directly compare features or relate to them at a personal level, and possessed a game-like dynamic. Keeping in mind the key features that we wanted to see in our design (lens, collaboration, tangible controls, and takeaways), we merged our ideas into one design.

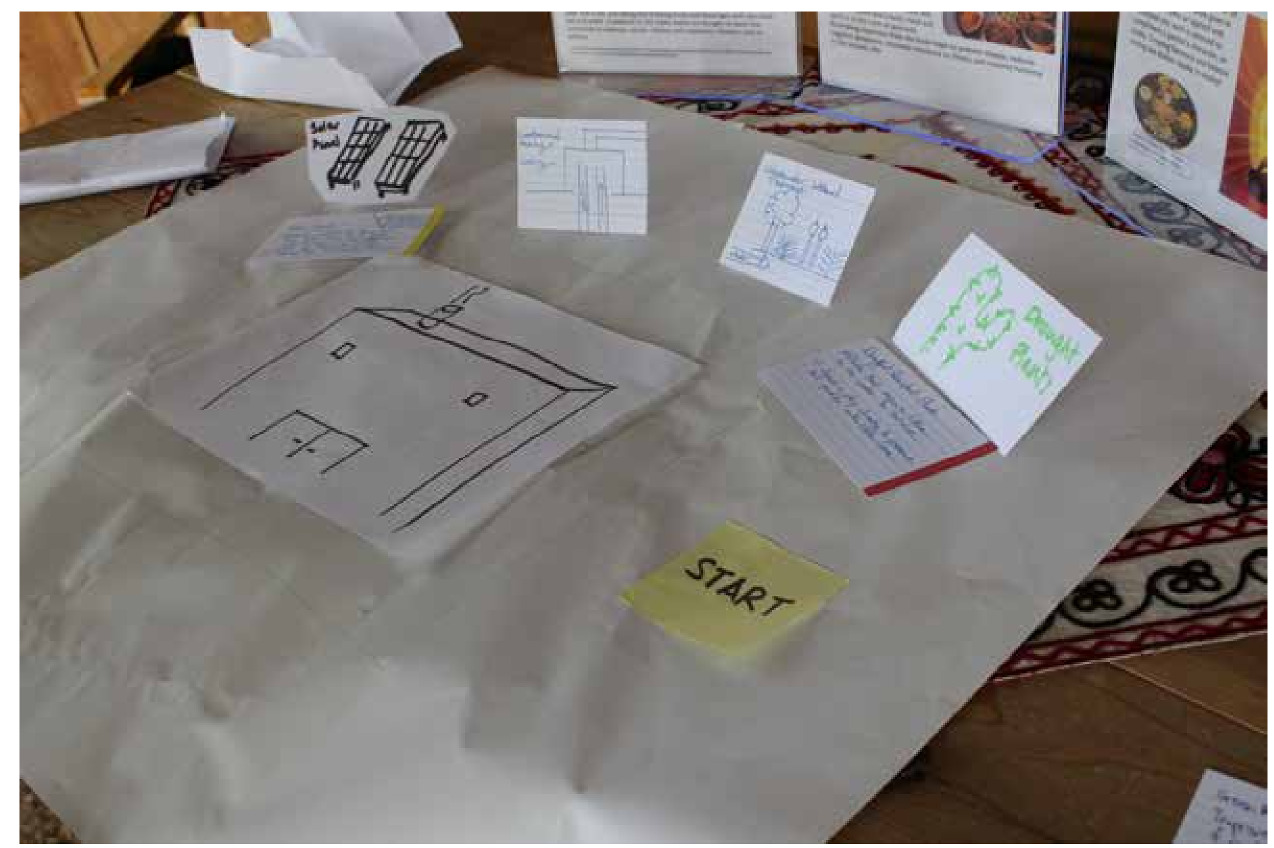
The low-fi design that we settled on is a tabletop game to allow for the comparison of features and simulation of data. We envision a touch sensitive table top, upon which users move physical pieces representing each of the different features of the Environmental Center. Users would be able to pick up and move these pieces (like chess pieces), the goal being to move the correct physical pieces into the center of the table, where they would effectively be added to a digital representation of the building.

Regarding gameplay, we wanted to give users tasks that would challenge them to learn about environmental features, and understand how they fit into an overall system. As a way to encourage deeper learning of the concepts, we wanted to be able to present different contexts for users to apply their knowledge. We also envisioned this as providing motivation for users to engage with the game, and to continue exploring content. For example, upon starting the game, users might be given the task to add features that would be relevant to a building in a desert environment. Users would then need to find out what features might be best suited in such an environment. They would be given the ability to see (through simulation) what the effectiveness and impact is of the features that they add.

Final Concept

PAPER PROTOTYPE

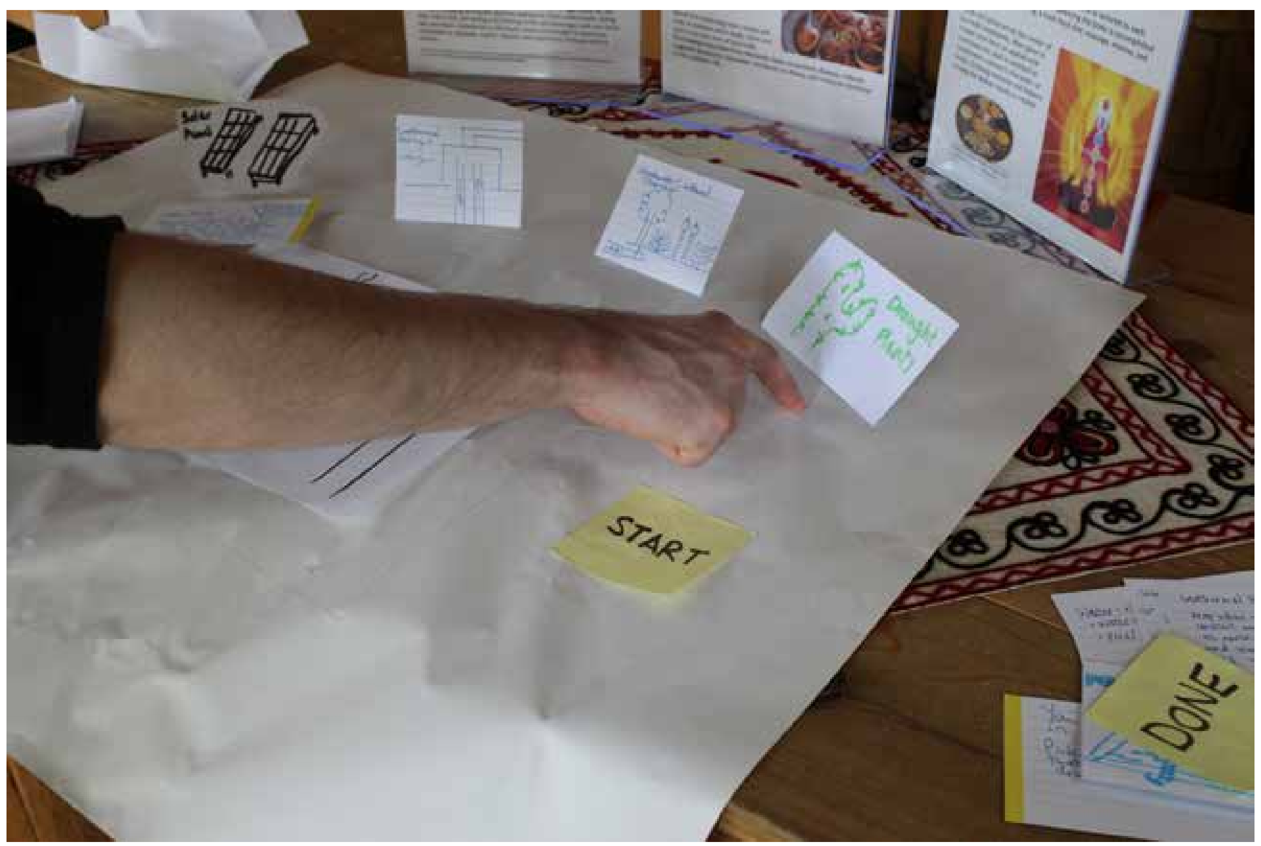
We decided to make a paper prototype of our design because it would allow us to quickly construct our concept to be tested with users. As a stand in for the touchscreen table, we had a large sheet of paper with a building drawn in the center. To distinguish the tangible features from our flat digital background, we made it so that the features would stand up vertically on their own. As users dragged these features across the sheet of paper, descriptions written about the features would follow along below the raised physical pieces. If users didn't know about a particular feature, the idea was that they could learn more from the description. In order to confirm a feature to be added, users would drag the stand-up pieces across the sheet of paper and place them within the building at the center.



USER TESTING

To test our low-fidelity prototype in an environment that is most similar to the Environmental Center, we headed over to Phipps Conservatory and asked a series of visitors to walk through our simulation. While there, we were able to work with four sets of visitors: an employee, two sets of young couples, and a mother with her young children. After the task-analysis we asked them some questions to get additional feedback about their interaction and their general experience at museums.

We also chose to conduct the task-analysis on some HCI students since they have UX design background and can provide more design and technical insights to us.



Feedback & Findings

To structure our findings, we gathered our key takeways, refered back to our exhibit visit framework and applied those lessons to the framework.

SURPRISE

Because we had to goad users into helping us out, and there was no possibility for an organic interaction with our prototype, this step largely doesn't apply at this stage in the process but will be accounted for in high-fidelity renders.

ENGAGE

As part of the interaction, users have to physically move the pieces to see addtional information about each system. This led to numerous instances of users staring blank-face at the board before touching anything, waiting for information to pop up. When they eventually went ahead and moved the physical pieces as instructed in our task analysis, they were more concerned with the physical movement and therefore missed the opportunity to explore each system more when the information window pops up. When we further develop the prototype, we need to account for this.

There was also little motivation for the users to complete the simulation, and once they did, there was no sense of finality. Once users pressed the "Done" button, in almost every instance, they waited expectantly for something else to happen. If we can motivate the user toward a sense of completion, then this problem is sure to stop.

LEARN

One of the major issues we faced across all users was the practice of adding features to the home without first learning about them. As our primary goal is to inform whoever decides to visit our exhibit, this is a problem. We need to find a way to encourage (or force) users to take in information without removing the fun they look for.

Common across all users was the desire for more information. For example, when learning about drought plants, an employee at Phipps commented, “I know that drought plants are good in the desert, but which type of plants are they? Are they daffodils? Cactii? I would want to be able to see a list of the plants”.

Similarly, we need to find a way to cater to people of varying age and ability to better accommodate this information transfer. Instructing a 35 year old mother versus her 9 year-old son requires vastly different resources. The young mother we spoke to mentioned that she would like to see more information about how applicable the systems are in different locations, especially locally. In contrast to that, a younger lady we spoke to, mentioned she would like to see more novel facts about each system such as “whether or not some drought plants are edible”.

APPLY

Derived from our Speed Dating process with the Soundscape team, we think having users personally involved in some way with the exhibit might motivate them to apply the information they acquire from us in the real world. One way of executing this is to put users in a first-person persective when they interact with the exhibit instead of addressing them as third-person. This way, users may feel more emotionally connected as opposed to discerning the experience as purely make believe and forgetting about it once they walk away.

High Fidelity

Final Concept

The concept for the game is to have players build their own environmentally sustainable building while learning about the various features that go into it. Players can choose from a number of different features, such as solar panels, geothermal heating and cooling, and rain barrels, which can be incorporated into their building. The game also allows for players to change the size of their building and the environmental region it is located in. All of these variables impact the overall energy consumption and savings of a player's building, so players are challenged to make informed decisions about the features they add. Furthermore, players are restricted by a budget that reflects real world costs, giving players incentive to weigh the up-front costs against long term benefits. At the end of the game, players are presented with a graph of their building's projected energy consumption.

The game is both digital and physical. We use a touch screen as the game tabletop, which displays the interfaces, screens, animations, and content that players encounter. The player's building is represented digitally and occupies the center of the screen. The game's physical components are the environmental features, which are unique 3D printed pieces. We track the position of these 3D pieces using a camera positioned above the gameboard. A key mechanic of the game is that when a player moves a 3D piece onto the touch screen, that feature is added to the player's building. To remove a feature, players simply take the corresponding 3D piece off of the touch screen. While a piece is on the screen, players can see important information about that feature, and click on surrounding icons to learn more.

Customization is a component we would like to emphasize in our game, and we want to give players control over how their building ultimately turns out. We believe that this will add to the open-endedness of the game, making it more fun to play and replay, while also enhancing learning. Since our game is ultimately an educational one, our primary educational objective is to provide players with a general knowledge of environmentally sustainable practices. Our hope is that the knowledge and insights acquired within the game can transfer to real world situations for users.

In the following section, we revisit each iteration of the prototype and explain the process as we improved on and tested with each version from beginning to end.

Eco Touch 0.5

MAJOR FEATURES

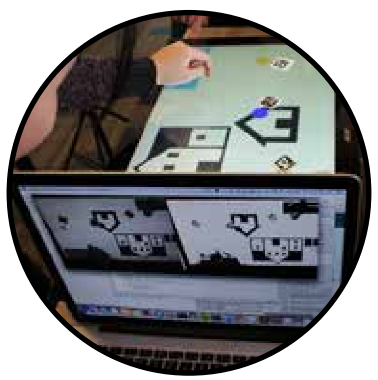
Game Art

Since the focus of the iteration was to explore technical details of the interaction technique, we kept the game art simple in this early prototype. We made a line drawing style black and white house illustration that sat in the middle of the screen. Attached to the house were animated illustrations of the three green features. The animations would play whenever a feature's correspondent physical piece was moved onto the house, signifying the feature was successfully installed.

Physical Pieces

One of the main points findings from our research phase we wanted to focus on

was making our exhibit multi-sensory. Keeping in mind that there should be a strong connection between the physical and virtual aspects of our game, we decided to incorporate a physical element that would be both engaging and representative. These physical pieces, as discussed in our low-fidelity iteration, represent the various sustainable systems individuals will incorporate into their building as part of the game. Models were chosen based on their representative system, e.g. a barrel for rain barrels. They were then 3D printed and associated with an augmented reality marker for tracking.



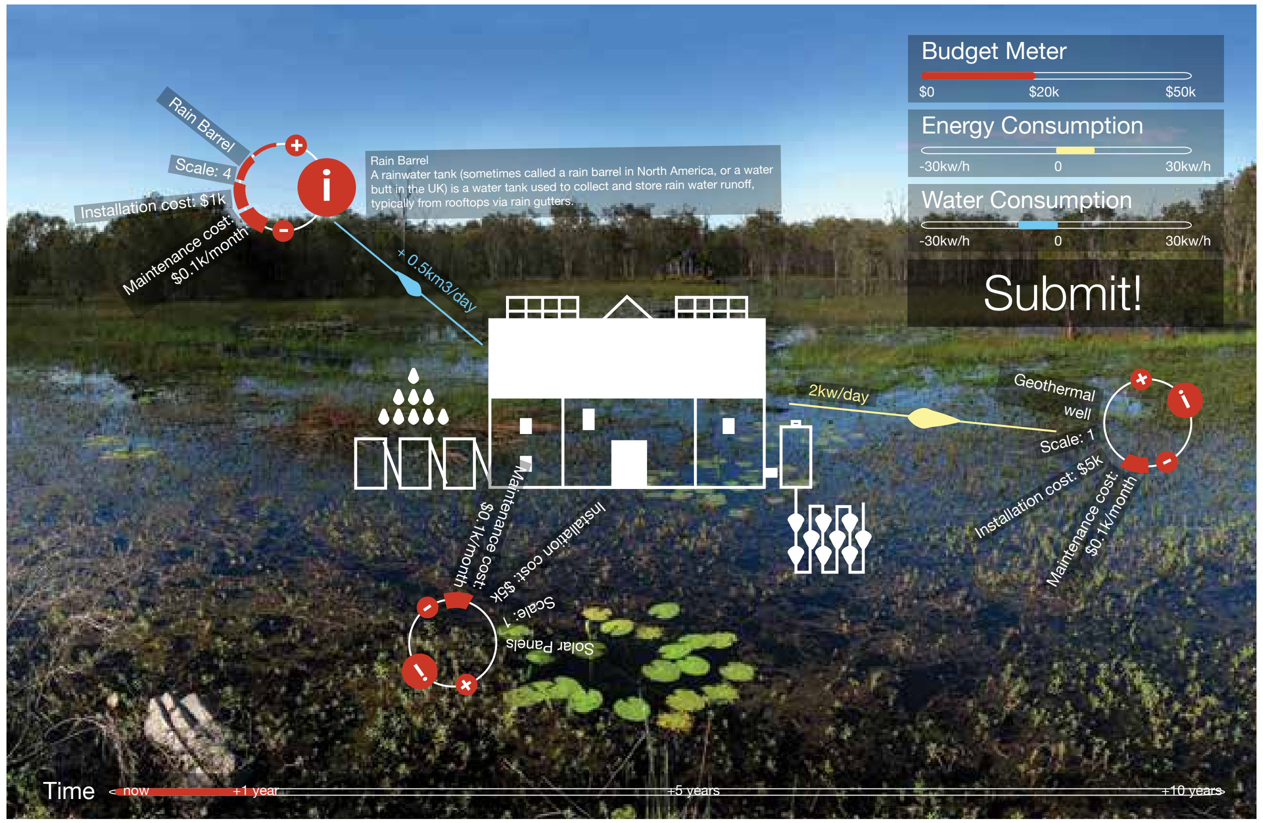
Camera Tracking

The bulk of work in this iteration was devoted to prototyping the system that tracked the locations of physical pieces. There were many possible ways to track these pieces, but after some research we decided to implement a camera based tracking system, in which we attached augmented reality markers to the pieces and tracked the markers from an overhead camera. There were several reasons that led us to choose camera tracking. Firstly, the technique required minimal extra hardware support, which was perfect for rapid prototyping. All we needed was a webcam and a few paper printed AR markers. Secondly, popular computer vision libraries already provided robust algorithms for marker tracking. In our case we used the ARToolKitPlus plug-in for OpenFrameworks and customized the plugin to have it communicate with various parts of our application. This way we were able to quickly confirm the feasibility of the tracking technique and integrate it with the rest of our prototype.

USER TESTING

Due to how many things were very readily in need of improvement and the tight time schedule we were on, we decided to forgo user testing in this round of implementation. We felt that our time would be better spent working on iterating a product that could stand on its own feet, rather than jumping the gun and testing with something that is very clearly incomplete.

Eco Touch 1.0

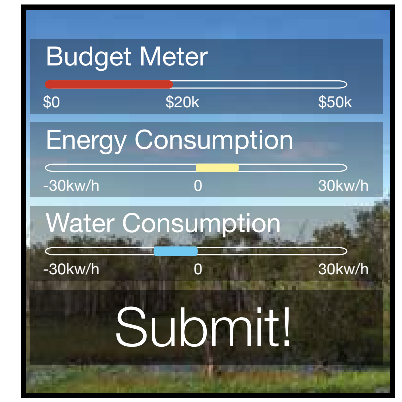


MAJOR FEATURES

Data Swirl

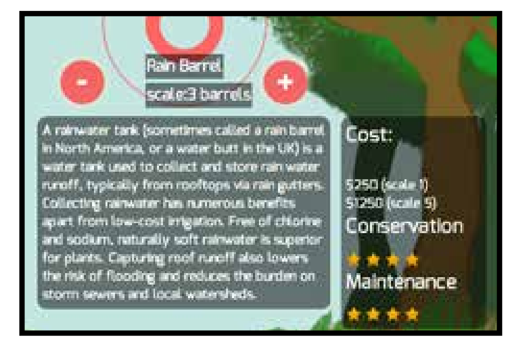
Data swirl was one of the two main UI features we introduced in this iteration. It is a circular panel that appears around and follows a physical piece whenever a piece is placed onto the screen. A data swirl contains buttons for bringing up the information panel, scaling the system, as well as information such as the name and cost of the system. We designed this feature to enhance the connection between the physical pieces and digital user interface, which was lacking from many museum exhibits we observed in our earlier museum research. In version 1.0, we had data swirls spin at a constant rate to make it more attention grabbing.

Budget Meter



The other major interface feature added in version 1.0 was the budget meter. Budget meter displays players' remaining available budget out of total available budget. We decided it was necessary to include a monetary measurement in the game because our expert interviews indicated that people understand cost the best in terms of money. It was also motivated by the game goal of version 1.0, which was to break even from money invested in green features in the shortest amount of time possible.

System Information



We realized that just having the house respond to the pieces placed on the screen does not provide enough information to individual playing the game. Therefore, we added short information summaries to each of the sustainable systems in their information panels. Additionally, in order to provide a more realistic simulation, we began to add system performance estimates, as well as typical home values for electricity consumption, water consumption, as well as water runoff.

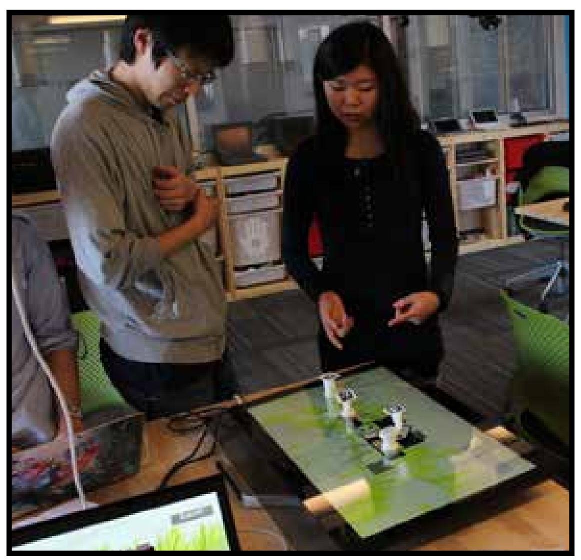
Prototyped Instruction

Since our game involves some prior understanding of the game mechanics, we wondered if players could figure out what to do and how to play the game simply with the existing affordances on the physical pieces and other UI components. We decided to paper prototype some instructions to get players started with the game. During our user testing, we conducted an A/B test in which some players received a step-by-step prompt telling them what to do, and others did not receive any instructions. The result of the test will be explained in the user testing section of this report.

Single Trial simulation

In order for users to be able to get a sense of the effectiveness of the systems they chose for the house, we wanted to enable users to simulate how those systems would affect things like water and energy consumption over a fixed period of time. At this stage in development this feature was rather limited, and really only afforded the user the ability to run the simulation once. However, even though it was rather limited, it helped provide a blueprint for what we wanted later in the development process.

USER TEST



Upon finishing version 2.0 we had scaffolded the first relatively complete game framework that allowed users to play through the whole experience. Eager to find out users' responses to the prototype, so we did user testing with eight users, all Carnegie Mellon students who did not major in Human Computer Interaction. We invited them to the FIG lab and conducted a 20-minute session with each of them. The users were asked to think aloud while completing tasks that would guide them through the whole game, from the instruction screens all the way to the final score screen.

Overall users were impressed by the tangible interaction design. Five out of eight users mentioned in their feedback that they enjoyed moving the physical pieces and watching the data swirl follow their movement. However, users commented on various parts of UI that needed improvement. Three users strongly disliked the spinning of data swirl. One of them said "Stop rotating! Can't do math when it rotates!". Four users failed to find out that the buttons around the data swirls were clickable, indicating that we needed to add visual cues to afford interactions. In many occasions people were confused by the lack of visual feedback to their actions. For instance, four users did not realize the change in budget meter as they installed features.

Aside from comments on visual aspects, we also collected inputs on the mechanics of the game itself. We found that most users struggled with finding the goal of the game, which was to buy features that would allow them to break even in the shortest time possible in version 2.0. This certainly highlighted the need to better define the game goal in the next iteration. Besides, seven out of eight users indicated they would like to see a more straightforward, yet more informative ending screen that would summarize their performance in the game.

Therefore we prioritized two goals for the next iteration of the game. The first was to further develop the game mechanics to define the goal of the game. The other one was to fix the glitches in UI such that they would not disturb the flow of the experience.

Eco Touch 2.0

FEATURES

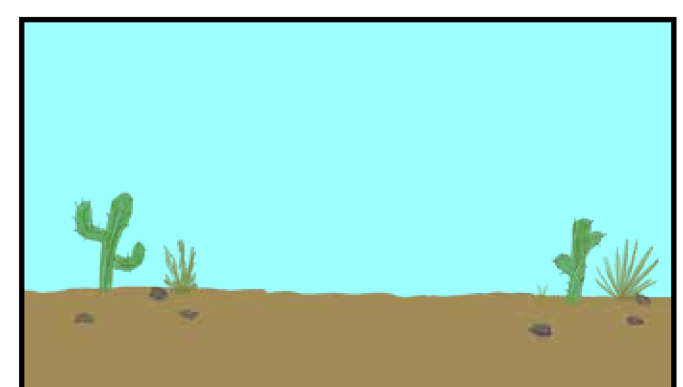
Instructions

Overall, we found from the A/B test in the previous iteration that players needed a little assistance to get started with the game. We therefore created a set of instructions at the beginning of the game that would provide a little background information regarding the game mechanics and overall game goal. Through this, we hope that most people can play the game with a little more knowledge on how to interact with the physical pieces and reduce some confusion.

Preferences

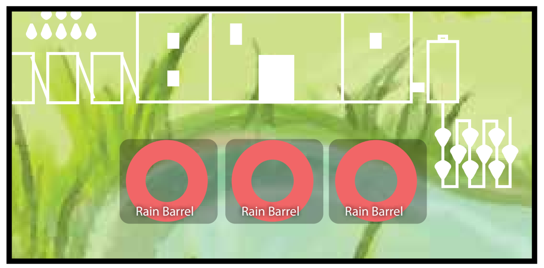
From our first round of high-fidelity user testing, as well as feedback we received from our low-fidelity testing, we realized that we wanted to incorporate user specified preferences into our game. Specifically, we wanted to include the ability for users to receive personalized feedback about the efficacy of certain sustainable features in their area. To achieve this, we first asked for individuals for a house size and next, to specify a location, using a Google Map, when they begin the game. The game then goes out and retrieves location specific information, such as climate (rainfall, temperature, rainfall event frequency), soil ratings (hydrostatic rating, composition), electricity utility rates, solar panel efficiency, and ground temperature. From this, we perform a series of calculations on each system to estimate its ability to produce or reduce a particular variable specified in our simulation. Because we wanted to make the information presented to individuals playing the game as accurate as possible, we use a collection of data APIs from both government and private sources. Lastly, we ask individuals for the number of members in their household as well as the size of their house so we can accurately estimate their water and electricity consumption.

Background



In terms of the aesthetic of our game, prior to this version we had been reliant upon either a blank background or a photograph to convey the environment. Beginning with version 2.0, we decided to move toward a more hand drawn look and feel. Thus we opted for a more painterly depiction of the background, reflecting a wetlands environment. This was done both to give our game a more vibrant and fun appearance, as well as to create a backdrop that relates to the sustainable message of the game.

Data Swirls



Since feedbacks from user tests indicated people found the spinning data swirl more distracting than attractive, we removed the angular rotation of the data swirl. We also changed the orientation of the text around the swirl and reduced the text length, because we learned that the spiky text design was very hard to read. To alleviate visual clutter, we cut down the number of buttons from five to three (the information panel button, the scale up button and the scale down button), providing access to only the most relevant functionalities. Overall, we maintained the concept of the data swirl but adopted a more minimal design.

Placement Slot for Systems / House Reaction

After testing version 1.0 of the game, we had several users tell us they didn't know how to attach a system to the house. Specifically, one user mentioned "Yes all parts were clear except for the part where I was supposed to figure out how to attach a well to the house." Based on this, we decided to create circular placement slots, so when a system if placed on one of these circles, it is officially added to the house. The circles are outlined in red when a piece is being moved in order to provide feed-forward to the user. When a system is placed in the circle, the appropriate animation is featured on the house signaling that the feature was successfully added.

Game Engine

Behind the scenes, we developed a game engine to handle the logic of the simulations. Rather than trying to generalize a lot of the functionality, we emphasized very explicit declarations of things like environmental systems so that it would be clear to everyone exactly what features were present. In addition, we tried to mask the internal behavior of the engine so that outside methods would only have access to the functionality they immediately needed. That way, once we were confident in how the engine ran, we wouldn't have to worry about anything on the outside modifying that behavior.

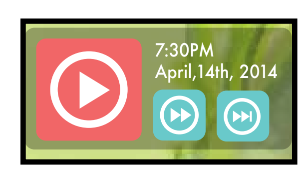
Budget Meter & Graph

To provide more visual feedback for the action of installing features, we redesigned the budget meter. Changes included increasing the meter's size, adding text next to the meter bar, making the bar's color change with the meter's value, and placing the meter in an individual UI panel. Since the addition of the simulation engine also demanded some form of visualization, we dedicated a bottom panel of the UI to graph outcomes of the simulation, including monthly water bill, electricity bill and water run-off. These parameters are plotted as lines in the same chart, with the horizontal axis being time and the vertical axis corresponding to various units of the parameters.

Ending Screens / Pseudo Ending Screen

Continuing on providing more feedback about the effects of installing a system on the house, we wanted to experiment with having an ending screen for the game that would provide more information about the decisions you made in the game. For our initial test of this ending screen, we just displayed a static graph to users and noted their response to it. Users through that the "The graph was pretty helpful, as well as the savings and costs." However, they thought that we could use more information on the screen, such as an overall score for the game, as well as a better annotated graph.

Pause / Play Simulation



After a round of testing, it didn't really make sense anymore to explicitly run simulations. Rather, we began treating simulations as a default behavior that users would have to opt out of, as opposed to one they would have to begin themselves. To aide in this, we developed the ability to pause the simulation at any time, along with the ability to resume it.

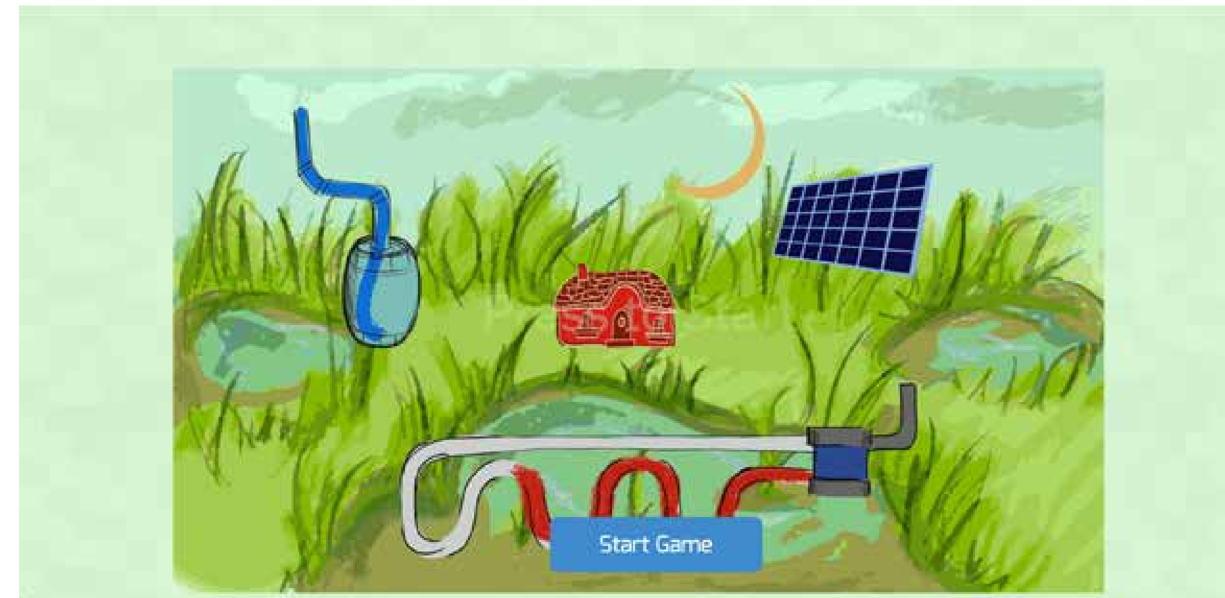
USER TEST

After adding so many features, we wanted to get some user feedback to determine the effectiveness and implementation of the new features. We ended up testing with just one user, because we found so many inconsistencies and room for additional work from just one test. Our user was able to successfully navigate the instructions added for this version, and get to the main part of the game, however she was still confused about the goal of the game from after going through the instructions. "I'm just assuming that my goal is to make the most money now". Continuing through the game, we noticed that she was having a large issue comparing the different rounds and noticing what round of the game she was on. Because we are trying to teach individuals about the impact of sustainable systems and their benefits, we really wanted them to be able to compare between having a particular system in their house and not having that system. Based on these two large items, as well as a few little things such as system size feedback, we decided forgo further user testing and continue to develop the game.

Eco Touch 3.0

(current version)

Screen 1: This is our starting screen. Players hit "Start Game" to begin.

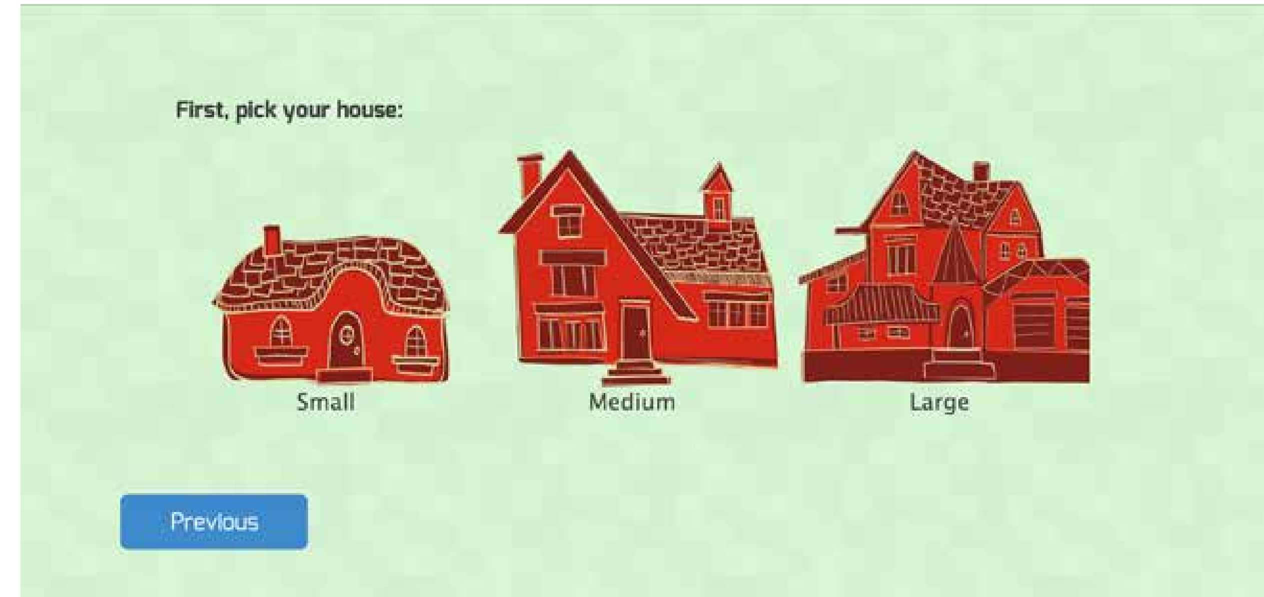


Screen 2: The is our first instruction screen.

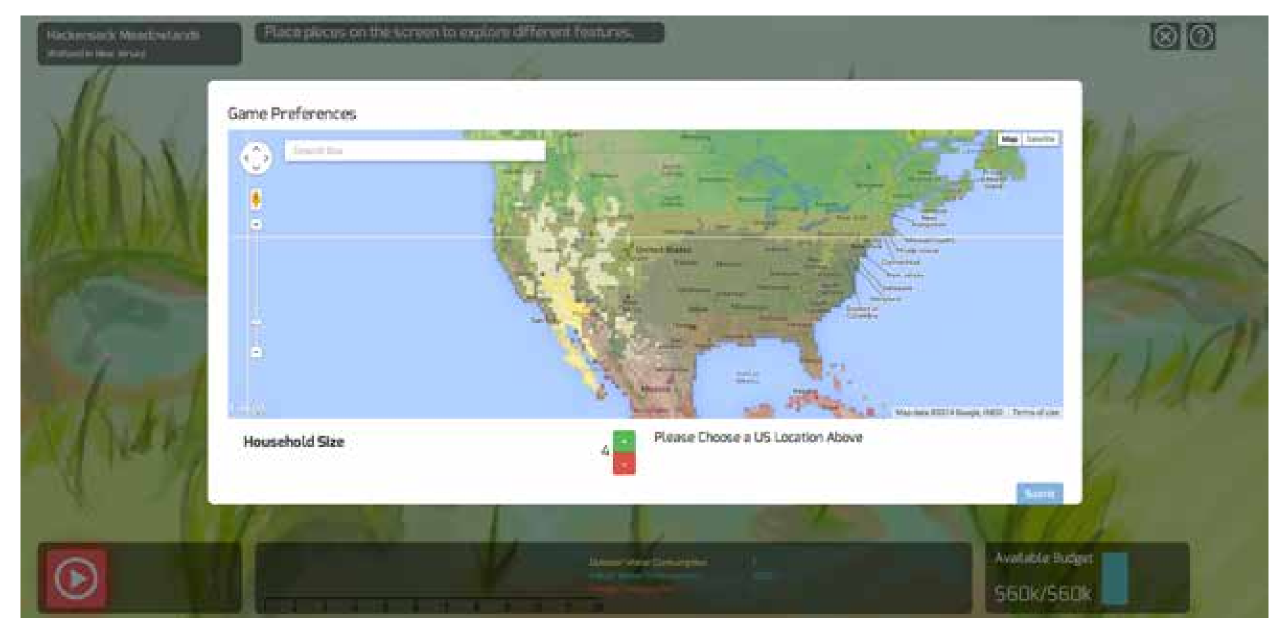
Screen 3: This is the second instruction page. It introduces physical pieces to the player.

Screen 4: The is our third instruction screen. It explains the the concept of the placement slot.

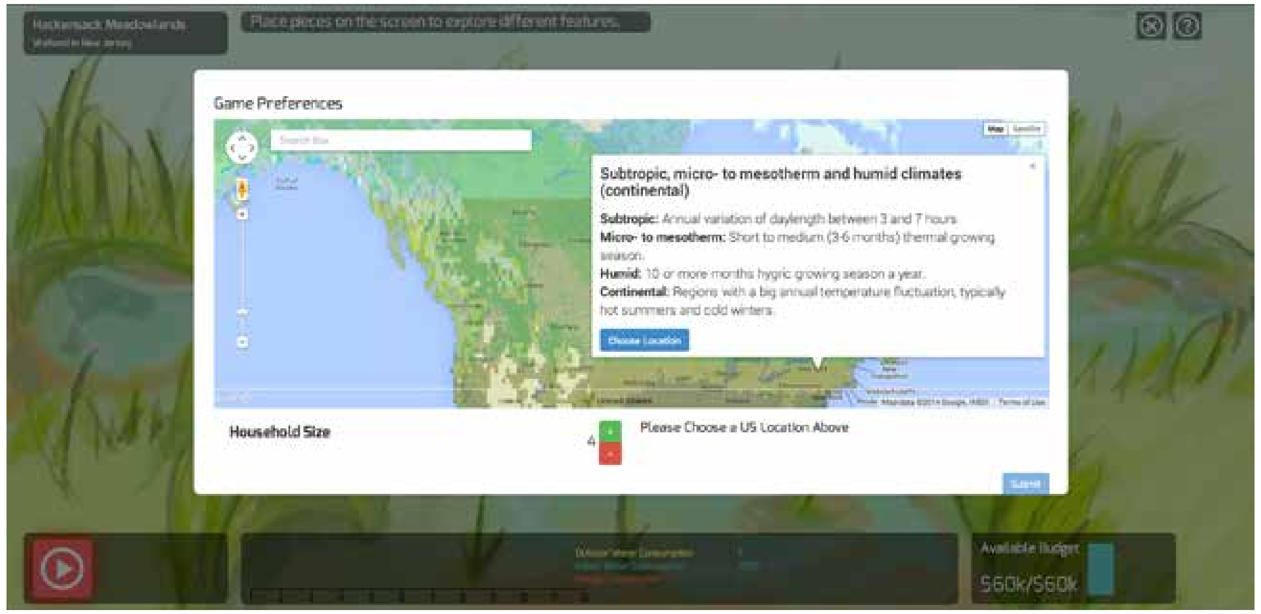
Screen 5: Player picks the size of house they want to play the game with.



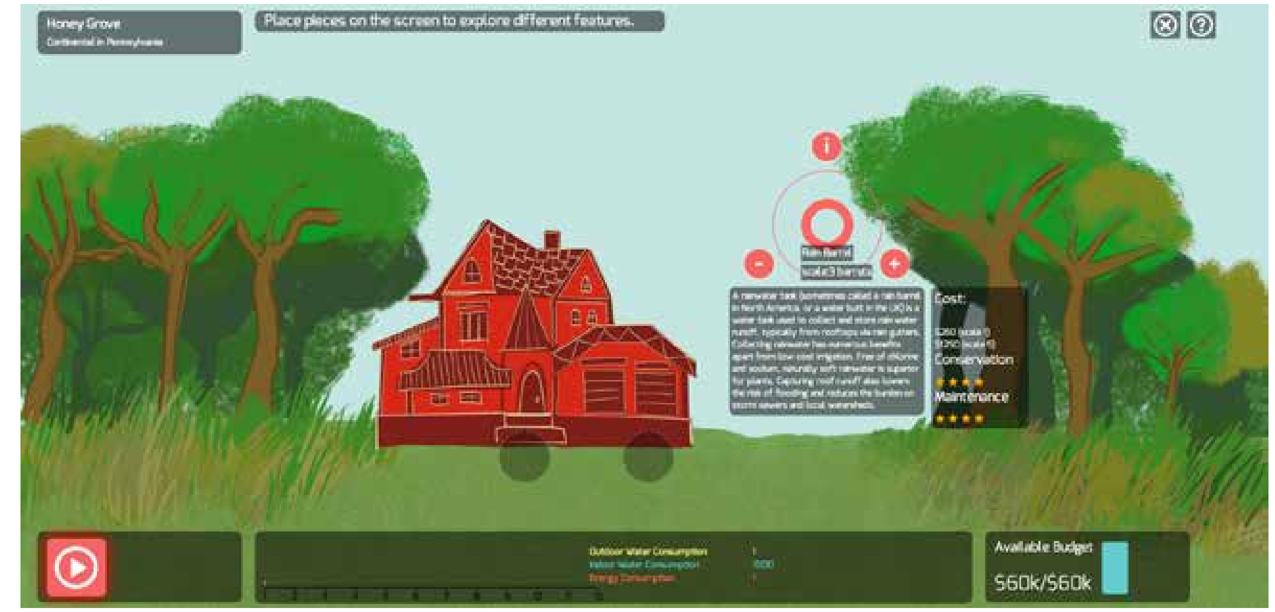
Screen 6: Player enters the location they are in or want their house to be in.



Screen 7: Climate information of that location pops up. Player then chooses their location and enter house size.



Screen 9: When the physical piece(s) is placed on the display, the data swirl shows up with a set of customization tools and basic information about that system.



Screen 8: Game page with the selected location biome and house size embedded in the visual setup.

Screen 10: Once the piece is placed in the slot, its respective animation for the house appears on the display.

Screen 11: The player hits 'play' and the animation of the system as well as the graph over a 12-month period begins to play.

Screen 12: Round 1 is over. A breakdown of the score and the graph is provided.

Screen 13: Players make adjustments to house installation in round 2 and hit 'play' again.

Screen 14: Round 2 is over, a break down of the score and the graph is provided.

Screen 15: During every round of simulation, a random selection of events can happen and can affect the score of the system installation.

Screen 16: At the end of the game, player has the option to enter his/her email to receive additional information about sustainable systems.

FEATURES

Game Start Screen

From our research, we knew that an important part of what draws people to an exhibit is having some kind of surprise or hook that grabs people's attention immediately. Assuming that our game is not always being played, we knew that the start screen would need to call out to visitors in some way. For this reason we decided to have our animations playing in a loop on the starting screen. Our intention is that this will serve as a visualizing interesting preview of the game, which along with a button and message, will prompt the user to begin playing.

Ending Screens / Pseudo Ending Screen

Because we added in multiple simulations to one trial, we needed to give users the ability to compare their performance from round to round. In our pseudo user test of version 2.0, our user noted "I wish i can write this (system information) down so i can compare it". Additionally, she got confused about which round she was on while playing the game. To alleviate this we added in a round ending screen. After each round, users are displayed with the graph of their performance, as well as a score for that round, with a system-by-system breakdown of their score. Finally, at the end, users see graphs from each of their rounds as well as their score from each round. Additionally, we asked our users for their email so we could email them about their choices that they made in the game and some suggestions for them. This was trying to get at the "Apply" piece of our museum visit model.

Multi-trial Simulation (Instead of pause/play simulation)

In this version, we decided to step away from the notion of one long, continuous simulation and break it up into discrete chunks that would essentially reset at the end. In other words, rather than have a simulation constantly run, the user would now have the ability to build a house without the pressure of time. When they were ready, they could begin a simulation that would last exactly one year. Then, they could repeat the process until they felt they were done. We chose to do this because from the previous iteration, it seemed confusing to have users think about time as being able to 'pause' and 'play'. By allowing them to decide when they were ready to start a new round again both serve a good consistent comparison and eliminates their anxiety of the time running out.

Changing Backgrounds

Since this version of the game allows for the user to pick the region where they build their house, we began to change the background of the game to reflect that decision. This relates back to our goals of providing a customizable and open ended experience, and we wanted to engage the user in a realistic way by having the game adapt to reflect user decisions. It also serves as a form of in game feedback, as the user can see that the environment matches the climate of the region they select. For example, if a user chooses to build their house in a hot, dry region like Tucson, the background image will change to a desert.

Animation Style / Art

Animations have been a part of the game since its original version, serving to engage the user, helping them to visualize how a particular feature functions, and working as a form of feedback to let the user know when a sustainable feature has been installed. Starting with this version, we reworked the animations to give them a hand-drawn look, more consistent with the background style of version 2.0. We also reworked the style of the houses, using hand-drawn strokes and more organic shapes. We also made the houses brighter and more colorful, in an effort to make them more inviting to the user. The overall artistic style is intended to be somewhat simple, so as not to distract users from the information on-screen, while at the same time conveying a sense of fun that our early, somewhat sterile design seemed to lack.

Events

To better capture the non-deterministic occurrences that happen all the time and to introduce another level of complexity to the game, we introduced the notion of events. That way, even if a simulation were run multiple times with the exact same features in place, the outcome could potentially be different on every run. The three events that we implemented were a rainstorm, a price hike in utility bills, and a drought. While we wanted to afford users the ability to feel like they were in control most of the time, we wanted this to be the place where they were forced to surrender some of that control.

UI Design Cues for Affordance

In addition to instruction prompts, we implemented a series of subtle visual cues to better afford interactions. They work in conjunction with prompts to guide players through the flow of the game. For instance, when a player places a piece on the table for the first time, we would highlight the installation slots to suggest that the next move involves moving the piece into the slot. Likewise we would highlight the play button when a player first installs a feature, indicating he could now start the simulation.

Instructions & Prompts

From our previous user tests, it was clear that some instructions are necessary to get user to understand the game. However, we found that some users skimmed or skipped the tutorial in the beginning of the game because they found it too lengthy to read. Those who did read the instruction did have less difficulty with the game itself, which supports our initial intention. In order to address players who prefer not to go through the tutorial page-by-page, we decided to add prompts throughout the first round of the game to show users where to place certain pieces and when to hit the ‘play’ button. The is done through some highlighting as mentioned in the UI Design Cues of this section. We believe that although this is a more subtle way of prompting users as opposed to a in-game tutorial, we also do not detract players from the game experience much.

USER TEST

After addressing the major issues that came up in version 2.0 and reworking many of our game’s features, we conducted a final round of user tests with five individuals.

We observed several key improvements in terms of game-play. By breaking the simulations into 3 rounds, users consistently seemed motivated to try new variations of features so that they might improve their scores. In this way, the goals and mechanics of the game finally became more tightly integrated into the educational objective (to get players to understand which features work best in particular environmental regions). We observed that users were thinking about

how they might optimize the available features based on a region's climate. In other words, players were no longer simply trying to add all the features at once, and instead they began to consider the effectiveness of a feature in terms of its cost and environmental impact. "I learned about the cost and effect of each of the elements in the system. I also started thinking about what would work better for different geographical areas." "I learned that a cluster of sustainable practices do not necessarily mean it's the best way to go about it."

Furthermore, we observed that adding a breakdown of the score and system performance at the end of each round was a step in the right direction. This seemed to be a useful form of feedback that guided users in their decision making. "I like how the results are very clear in terms of reflecting the purpose of the game. It's very easy to compare and see what system works the best." However, we also noted that many users expressed interest in having some sort of baseline for comparison or a more clear way to interpret their score. "I kind of wanted to learn more because I was a bit confused about my score." Moving forward with the game, we would anticipate grounding scores in such a way that users have a direct way to gauge their performance. Perhaps showing how the house would perform without the sustainable features could provide useful context initially.

We also observed that some users struggled to find and bring up the additional information about each of the sustainable features. While much of this difficulty seemed to stem from the fact that our camera tracking was not calibrated perfectly, and the icon was partly obscured, it might also be necessary to make an icon with greater visibility. Having a designated area or information panel on the screen for feature information could also be a potential solution. "It'd be nice if there's a screen/chart to compare each piece. I think it will help users understand more about different options."

The overall visual style and technological novelty of the game were aspects that users universally enjoyed. The hand-drawn aesthetic, combined with animations and changing backgrounds all went over well with our test subjects, grabbing their attention and keeping them engaged. Similarly, users found the combination of digital and physical components to be interesting. "I enjoy the cute icons and fun style that the game has. It is cool technologically, seeing as everything has to do with a touch screen and camera. It would definitely appeal to a younger audience." "I liked the animation and design. It's a cool game, works pretty well, and looks good."

Finally, in terms of providing users with some kind of takeaway or follow up after playing the game, 2 out of 5 expressed that they would enter their email address in order to receive further information about sustainable building practices.

Future Considerations

SCREEN CHOICE

For the final game, we envision a large touch table-top game. According to our research, collaboration is a key aspect to a successful exhibit interaction. Although our game does not support multi-player, we think it does generate conversation and is a fun experience to people traveling in groups. People can play the game together as a team if the screen size is large enough to support that. Ideally, we would have a larger touch screen with more interaction space so more systems can be implemented.

NON-CAMERA INTERACTION

Right now, our game relies on a clear view from the camera overhead to the tops of the game pieces. If this view is obstructed by something like a person leaning over a piece, that piece goes incognito and disappears from the screen. Going forward, it would be ideal if we could remove this limitation and utilize the functionality of a touch table to allow the pieces to be detected sitting right on the table from its base instead of from the top. Some touch tables in the market support numerous touch points on the display which would allow the physical pieces can be uniquely identified from the base of the piece. Microsoft PixelSense is another alternative. It comes with a camera embedded, which allows for camera capture but coming from the bottom of the table instead of from the top.

MEANINGFUL SCORE

The score that is displayed after each round of simulation doesn't really mean much right now. There are no units on things like water consumption and energy consumption, and we got repeated feedback that the numbers by themselves mean nothing without things to compare them against. In the future, we should refine the score calculations to impart some tangible meaning (gallons of water saved, money saved, etc.) In addition to reporting past scores so there is a benchmark for comparison.

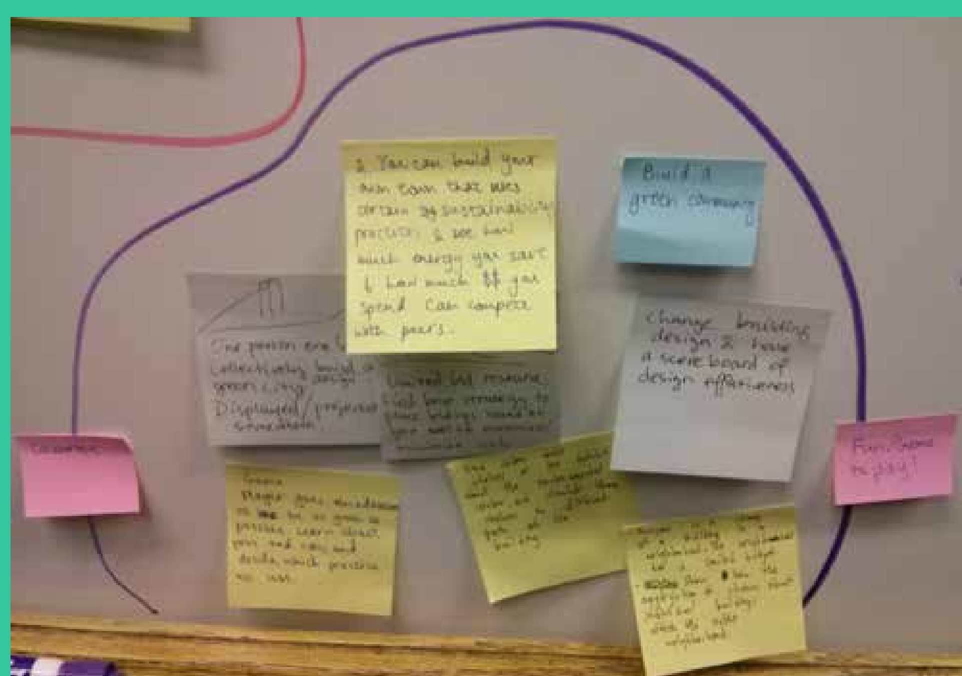
TAKEAWAY FOR USER

One of our goals initially was to implement some kind of tangible takeaway for every user that visits the exhibit, to increase the chances of application of the knowledge they gained after they leave the center. We asked several users during our user test to enter their email if they want additional information about sustainable practices. A few users did enter their email. However, the rate was lower than expected. Our initial idea was to have each user take a picture with their house, then send an email to them containing both that picture and other information about sustainability. If given a little more time, we could test this area of the exhibit a little more.

MORE GREEN FEATURES

There are currently only 3 sustainable features: solar panels, geothermal heating/cooling, and rain barrels, implemented. However, there are a large number of sustainable systems that an individual could add to their house that could be better optimized for their need and budget. These include high-efficiency appliances, a rain garden, and greywater treatment systems. Some of these systems have been implemented in the back-end, but do not have a corresponding front-end component, and some are missing both components. Ideally, in the finalized version of the game, there would be approximately 6-8 features that individuals could choose to include into their home.

Appendix



Ineffective Design

Small displays aren't noticed by guests

- Stars and Moon iPad screen not noticeable
- Screens in the monster exhibit were far from the interaction and were too small
- Monster exhibit iPad not well noticed

Boring Exhibit

- Space history display has a lot of text - so couple get bored and walks away
- Dinosaur simulator "super boring" - but played with it for 10 minutes

Poor instructions decreased popularity

- Monster-scope exhibit was unpopular -- it was noticeable but no one knew what to do
- Watershed exhibit at natural history had no instructions and was too open ended -- no goal
- Little kid reaches into the display w/ a warning sign -> still ignored instructions
- Moon + Star - not many people know how it works and just walk by
- Older people and health robot -- don't understand how to get it to move. Spend several minutes figuring out interaction

Lack of Affordances

- Monster-scope exhibit -- people didn't realize they could interact with it
- Distance from physical exhibit and digital display prevents children from making connection
- Heath robot controls were complex and did not map well to the simple example
- Air hockey display design doesn't let you interfere w/ the robot

Attractive Features

Large object attract visitors

- Exhibits at a large scale attacts users and help them understand interractions
- At children's museum, scale of giant ball track really appealed to individuals
- The scale of the ball exhibit allowed passive participation in the exhibit

Movement attracts visitors

- Talking robot (that made annoying noises) has spinning gears -- robot popular
- Water exhibit was popular, kids like playing with water
- Exhibit that you can move around in and build objects are fun and intertaining

Loudness attracts people's attention

- Nathan playing with metal washers really excited a little boy
- Talking robot really intrigued people -- also annoyed them
- Star and moon piece -- when people were playing with it, it attracted more people

Kids are drawn to lights

- Kids drawn to light pegs/ fiberoptics. Really appeals to toddlers
- Children's museum light-bright exhibit appealing to smaller kids
- Little hirl ran towards a giant beam of light.
- Science center lasers were intriguing b/c LASERS

Staff interaction at exhibits

Staff show proper exhibit use

- Need staff to demonstrate proper use of circuits in the children's museum
- Staff were enthusiastic about answering questions maker questions at children's museum
- Conductors at science center really enthusiastic about the subject of trains and explaining it to guests

Staff help engage visitors

- Employees at parachute drop in both children's museums and science center
- Conductors in the science center help to explain exhibit to users and show them interesting facts

Staff and Regular people help fix exhibit problems

- Guy hurries over to help girl get the ball rolling in children's museum
- lady @ the tilted floor exhibit -- standing next to it to make sure children don't hurt themselves
- Air hockey robot -- there is a staff person right next to the game to prevent ppl from sticking their hands in the robot zone
- Conductors at trains helped to encourage interactions + show people connection to their local area

Staff cleanup exhibits

- Kid threw rock and made a mess. Staff had to pickup / clean up the area
- staff at children's museum craft station clean up left overs
- Staff in children's museum paint area manage paintings, and help people put them through the dryer

Disconnects

Exhibit doesn't fit demographic

- In natural history museum -- touch screens fun to play with but kids don't learn anything
- Monster exhibit give different experience to people of different heights
- Children don't understand the feedback from the capacitive touch exhibit in children's museum

Disconnect between technology + physical part of exhibit

- Health robot -- Justin did not realize it was controllable. Relationship between panel not clear
- Very young kid didn't pay attention to digital display in capacitive touch exhibit
- Old people didn't understand the controls + connection to health robot in science center
- Parents and daughter tried to get the robot to dance, however the interface stopped responding. Eventually left b/c there was nothing else to do w/ the robot

Exhibits need proper location

- First impressions matter (location).. people were more likely to visit talking robot than health robot b/c it was the first thing you see in the room
- Health robot in corner not noticed very much in science center
- Solar panel car exhibit in science center not noticed b/c it was in the corner

Parents + Their Kids

Parents stay + interact w/ exhibit after kids leave

- Kids interact with robot first, see it dance + walks off leaving the dad alone. Dad plays with the interface by himself
- Kids drag dad over to play with exhibit and then left them after
- Dad stays and plays with the game being tested while the kid is bored by the virtual interaction

Parents explain exhibits to kids

- Parents took active role in exploring how exhibit work w/ video display @ Children's museum
- Kid asked parent questions and got explanations @ Nat. History while brother ran around and played
- Children's museum RGB display explained to kids by parents + guided how to use item
- Kid playing w/ globe touch screen -> parent helped to explain info to the kid playing with it
- Kids playing with dinosaur exhibit + parent gets the opportunity to explain the diff. dinos to the kid

Kids making up stories

- Little girls running around and making up stories about the dinos @ the Nat. History museum

AEIOU

Activities are goal-directed sets of actions—paths towards things people want to accomplish. What are the modes people work in, and the specific activities and processes they go through?

Environments include the entire arena where activities take place. What is the character and function of the space overall, of each individual's spaces, and of shared spaces?

Interactions are between a person and someone or something else; they are the building blocks of activities. What is the nature of routine and special interactions between people, between people and objects in their environment, and across distances?

Objects are building blocks of the environment, key elements sometimes put to complex or unintended uses (thus changing their function, meaning and context). What are the objects and devices people have in their environments and how do they relate to their activities?

Users are the people whose behaviors, preferences, and needs are being observed. Who is there? What are their roles and relationships? What are their values and prejudices?

NO.	ACTIVITY	ENVIRONMENT	INTERACTION	OBJECTS	USERS
1	Parents want to take interesting/memorable photos of their children at the exhibit	Children's museum projector photo-taking wall. Aesthetically pleasing / interesting / large exhibit booths suitable for taking photos.	Little girl ran towards a giant beam of light and her parents noticed her picture projected on the wall. Parents attempted to recreate that so they can take pictures of the scenario.	Projector, wall that picture is projected on, light (as the key initial attraction)	Young parents (late 20s, early 30s) daughter
2	Look at the exhibit on bicycle brakes	Open layout -- has enough space for a group of individuals to view the same exhibit simultaneously	Touch the exhibit / perform an action either afforded by the exhibit or written on it	Bicycle brakes, and exhibit handle	A dad, and his two younger; ~10 year old daughters.
3	Family of three wants robot to say/do something interesting.	Science center entrance to Roboworld	Parents tried to work with their young daughter through a touch-screen interface to get a robot to dance/ say something. The interface worked initially but then stopped responding to their touches. They stuck around for a while but eventually left the exhibit in frustration.	Touch-screen interface. Robot	Two parents. Young daughter
4	A boy worked on connecting circuits	Makeshop in Children's Museum	The kid stayed for longer than 15 minutes, playing around with circuit boards on his own.	simple electronic components (switches / light bulbs /...) mounted on wood blocks	One little boy (around 8-10 years old?)
5	Building fort structures out of modular pieces	Pre-existing structures for kids to connect their pieces to, open area for building, additional pieces situated by back wall	Kids connect pieces together using screws and washers, build up on larger structure	square pieces with holes for connectiing, screws, washers	young children - capable of building with large pieces
6	Little girl tried to deploy a ball on a track that surrounded the room.	Children's Museum room.	The young girl had to pull her hardest on a pulley to get a ball to leave its holder and deploy on the track. She became frustrated as she couldn't muster enough strength to do it. A man then hurried over and took the rope to deploy the ball.	Pulley with holder for ball Track that ran throughout the room	Little girl Helpful man

15	Visitors playing with the health robot	Science center in the robot exhibit -- somewhat hidden to the side	An older couple wanted to get the healthcare robot to move around. They tried to use the interface, but it took them 3 minutes to figure out what the right button was. When they got it to move, the motion sensors on the robot also bugged out and it would stutter when moving.	Touch screen interface -- also a moving robot with motion sensors.	Older couple in their 50s.
16	Kid being entertained by washers moving down a large screw	In the nursery exhibit in the Children's museum.	No one was interacting with the washer + screw exhibit. I went up to it, and picked up some of the washers and dropped them down the screw. A kid then ran over -- very excited -- and performed the same action	Washers on a screw -- on an isolated stand without a display/note on the interaction.	A young child (about 4 years old)

7	A dad and a boy lifted a ball with a pulley up to the entrance of a track that went around the dome of the room.	Garage exhibit in Children's Museum.	The dad and the kid lifted the ball with a pulley but the ball got stuck at the entrance and couldn't enter the track. After pulling the rope a few times the ball eventually went through. A while later the ball fell out the track and dropped to the ground.	Pulley, rope, a track that surrounds the dome of the room.	A boy and his dad
8	Kids interacting with robot at science museum and drags dad over	In the front section of the robot floor. Robot does little dance with flashing lights and sings to attract more visitors	Kids interact with robot first, sees it dance and walks off leaving the dad alone. Dad plays with the interface a little by himself.	Robot, interface screen, location of the robot	Three kids from age 9-14. Dad
9	Mom and four kids exploring the dinosaur hall of the natural history museum	Hall was quite empty; mom and kids had the entire hall practically to themselves. Didn't really need to share anything.	Little boy ran around the area and banged on the screens	Giant dinosaur models and recreation of environment in the Jurassic period.	Four kids from 4-9
10	Same as above	Same as above	Two girls stood in front of an interface for over 10 mins discussing what they like about dinosaurs	Every dinosaur had an associated touch screen device with more info about the dinosaur	Mom
11	Same as above	Same as above	One girl interacted with interface, became confused and asked mom for help.		
12	Same as above	Same as above	All of them reconvened at the video section of the hall / end of the hall		(Note -- museum fatigue)
13	Visitors ignored an interactive sculpture on a wall (Moon and Stars Exhibit)	Hallway in Children's museum, outside the garage room.	The sculpture received much less attention than the pieces next to it. Most people passed by the hallway without realizing it was interactive. Then some visitors saw the researchers play with the piece and started trying it out.	The sculpture was about 15 feet wide and 6 feet tall. It was a mostly flat piece, with a moon at center and surrounding stars.	Parents and kids
14	Young couple interacting with historical touch display	Science center -- in the space exhibit	A couple walked up to this touch screen display, and played with it for 2 seconds. But it required a lot of reading, so they just moved on to something that didn't have that much text	Touch screen panel. Had a time-line interface	A young couple in their 30s

RESEARCH: LITERATURE REVIEW CITATIONS

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LOW-FIDELITY: USER TEST

Task Analysis

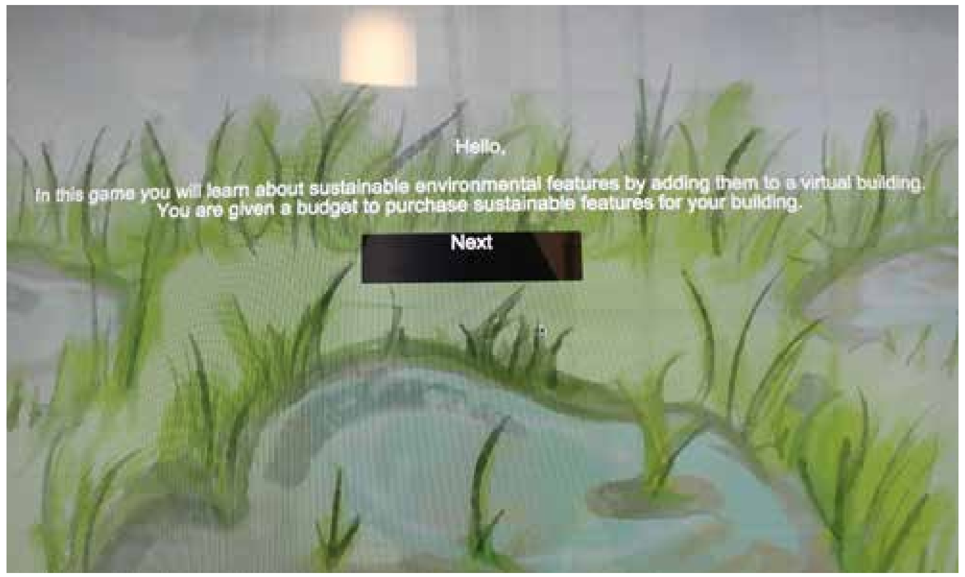
Tasks:

1. Start the game.
2. You are tasked to build a green building in the desert
3. Tell us the difference between wetland water treatment and drought plants
4. Add sustainable systems that you think would work well in this scenario
5. Whenever you are ready, confirm your building design.

Questions:

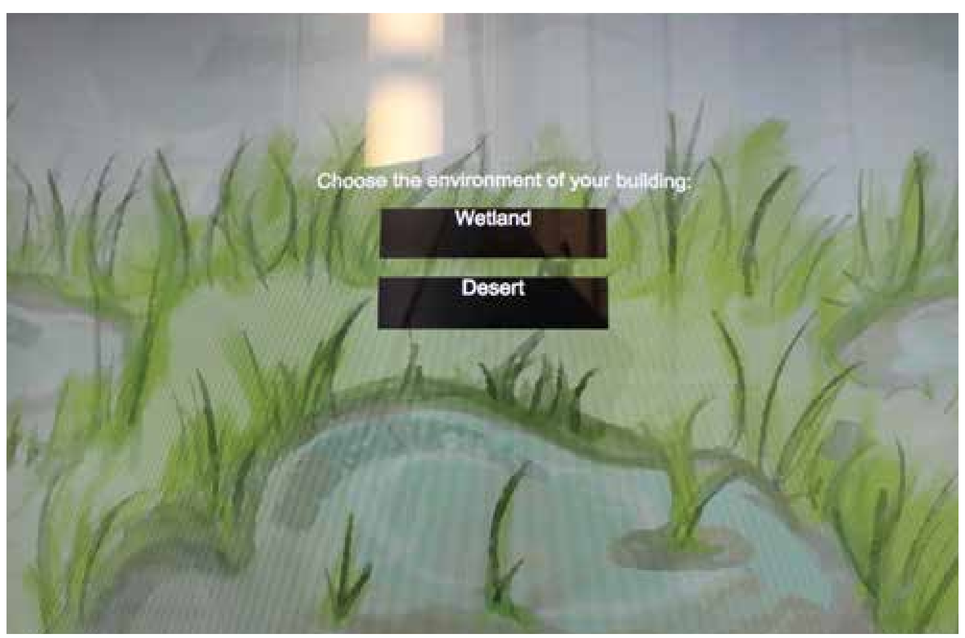
- What do you remember about any of the sustainable systems you added?
- What did you like or dislike about the interaction?
- What did you expect to happen once you pressed the "Done"?
- What do you think if you are able to take a photo after the interaction?
- Wall projection?
- Anything else we want.

HIGH-FIDELITY: ECO TOUCH 1.0

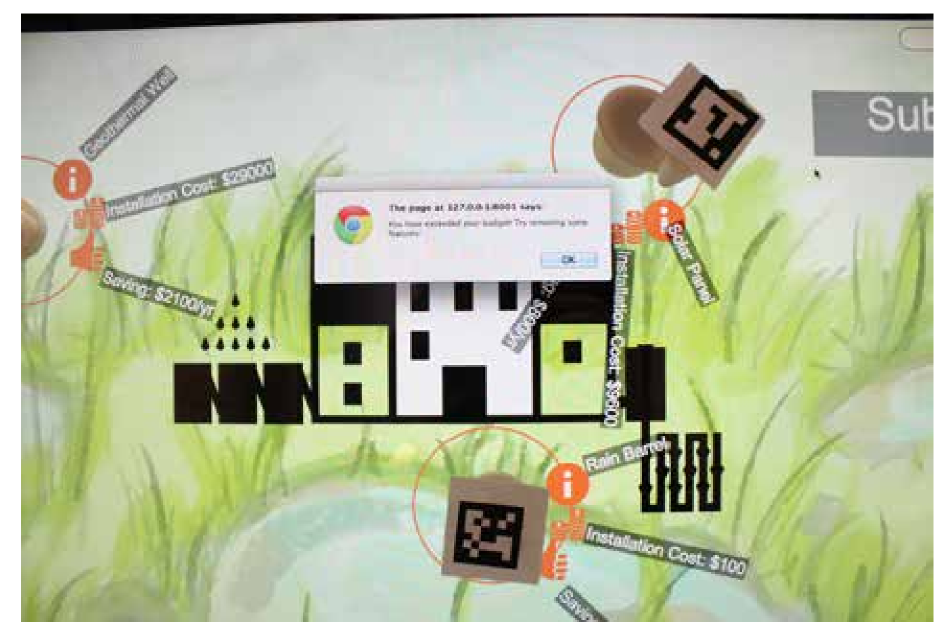


Instruction screen

Once user decides on the building environment, they are taken to this screen where placing a physical piece on the display will trigger the relevant animation and also some infographics to provide additional information about that system



Users can choose an environment



If the user tries to submit when the budget meter drops to zero or below (shown in the previous screen), a budget-exceeding message pops up and prevents user from submitting

HIGH-FIDELITY: ECO TOUCH 2.0-3.0

This picture is a screenshot of Eco Touch in the process of development right before the 3.0 version. At this point, the play/pause function is still present. We eventually removed that functionality.