Natural Resource Conservation for Children
Evaluation

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Evaluation Techniques

To evaluate our prototype, we initially conducted two informal heuristic evaluations performed by peers of our HCI degree. Based on the feedback generated, we made some minor adjustments to our prototype design, before presenting to users. We then performed user evaluations using techniques such as pretest and posttest activities, observation sessions and semi-structured interviews. We had 7 participants in our study, 4 female students and 3 male students from a small private school in eastern Atlanta. The children who participated were aged 7-9 years of age and were part of a mixed 2nd and 3rd grade class at the school. There was also a school teacher, supervising some of the sessions, who also provided some feedback on our design. The team conducting the evaluations consisted of three members: one person interacted with the participant by providing instructions and conducting the interview sessions, one person timed the tasks, and one person t written notes.

To evaluate our system, we followed the testing protocol outlined in our earlier report. To measure the level of existing environmental knowledge, each participant was first given a simple recycling sorting task as a pretest. Participants were given 10 objects (glass bottles, aluminum cans, plastic bottles, jars and cups) to sort into 4 labeled bins as they deemed appropriate (Figure 1). This task was timed.

Figure 1: Pretest (left set) and Posttest (right set) recycling exercise

We then conducted observation sessions of the participants as they carried out the three following critical use cases with the system prototype. Our prototype was demonstrated on a laptop computer, and participants interacted with the game using a mouse. During the observation sessions, we also asked relevant questions and elicited feedback in context to some of their actions. Participants were first asked to enter the Eco Island game, and inspect the initial state of the island. They were then asked to wash their hands at a nearby bathroom, while accompanied by one of the evaluators who timed this task. The states of the game were changed using the "Wizard of Oz" technique. The evaluator who accompanied the participant communicated the time taken to wash hands, to another evaluating team member. This other evaluator then changed to state of the island accordingly, to reflect the amount reward that would be received by the user. Participants were then asked to inspect the changed state of the island, and make comments, before clicking on an icon to receive coin rewards.

The second use case involved playing a mini-game in Eco Island. Participants were first given instructions regarding how to play the game, and the objective of the game, before beginning. The mini-game is a timed and scored activity, where participants are required to sort items flowing down a river in the correct bins within 30 seconds (Figure 2).

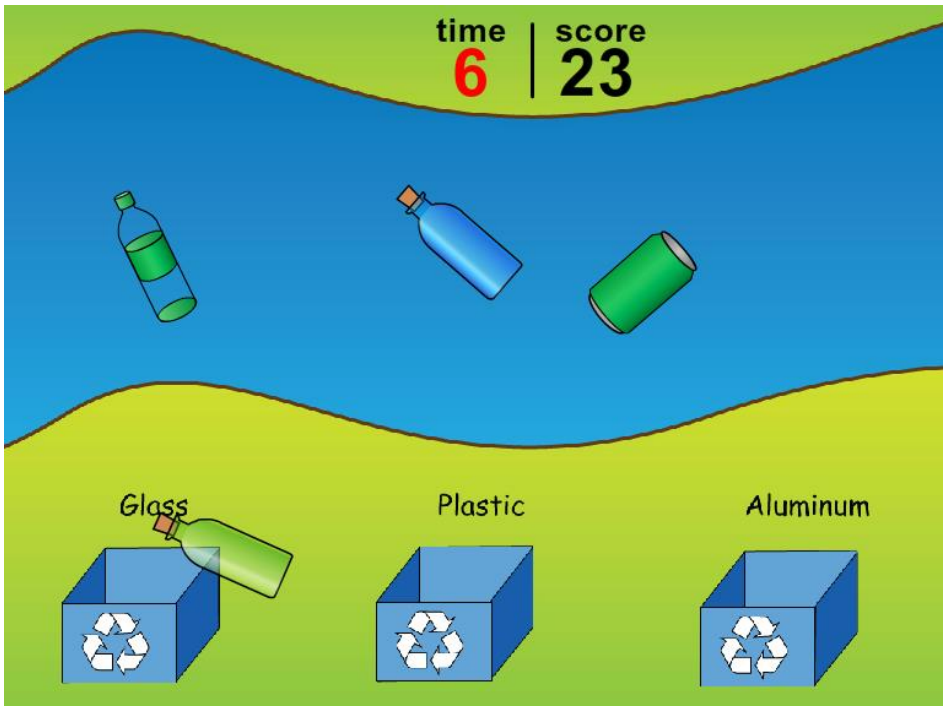

Figure 2: Recycling mini-game as a part of Eco Island

The final use case involved rewards collection, personalization and socialization. Participants were asked to decorate their *Coconut hut* (Figure 3), with different items provided on a menu. Then they visited and inspected a hut of a neighbor in Coconut village, before finally returning back to the totally island view.

Figure 3: Coconut Hut

After participants had interacted with our prototype, we interviewed them about their experience and understanding of our system as well their general existing resource conservation habits. The interview was semi-structured, consisting of 6-8 questions and lasted approximately 5-7 minutes. Finally, participants were asked to complete another real world recycling task as a posttest to our evaluation process. The posttest was a repetition of the pretest activity except with a different set of items given to sort. The time taken to complete the posttest was noted. The purpose of the pretest and posttest was to determine the effectiveness of the educational content of the Eco Island mini-game.

Results

Qualitative

The qualitative results of our study can be divided into two main sections: observations made while the users were completing the critical use cases, and the users' responses to the interview questions.

Use Case 1: View Aggregate Information

In general, the users had no trouble interacting with the welcome screen, pressing enter and progressing to the island view. When asked what they noticed, all users mentioned the salient features such as the volcano, river, and houses. One user spontaneously stated “I don’t know how to play this game” upon seeing the welcome screen, but didn’t have any trouble with the game mechanics after that.

After washing their hands and returning to the game, many users did not make the expected observation that the water level of the river had gone down. All but one did notice a change in the river, but only one user said that there was less water. The others all mentioned the change in color around the river, but did not recognize this change as indicating a lower water level. The general reaction to the coin reward screen was neutral.

Use Case 2: Mini Game (recycling sort)

The users were told to sort the items into the appropriate bins as they came along the river. The users who received these instructions all correctly used a click, drag, drop sequence to accomplish this without requiring further instructions. While they understood the concept, it seemed that the objects were moving too fast for many of the users to easily click on them. In fact, several users spontaneously mentioned that the objects in the sorting game moved very quickly. One user pressed the start button before receiving instructions and was confused. There was a glitch while one user was playing the mini game that caused it to return to the previous screen. The user was momentarily disoriented but was able to return to the game easily.

Use Case 3: Customize Hut and Explore Other Users’ Huts

Once again, users had no problem with the click, drag, drop sequence when told to place items on their hut. Most users had a positive reaction to the customizable coconut huts, although

one user stated, “I don’t live in a hut” and seemed skeptical about the coconut village section of the game. Two users in particular seemed to particularly enjoy decorating their huts and asked questions like “can you make it [one of the decorations] bigger?” The users were about evenly split between those who did click on the animal pets and those who did not. When told to navigate to another user’s hut and then back to the island, all but one user easily found and used the signpost navigation.

Responses to Interview Questions

We began by asking users their general opinion about the game, what they liked and didn’t like, what they would change about the game, and if they thought they would play the game on a regular basis. These questions were a bit abstract given the age of our users, so the answers were not particularly useful. Most users said they liked every part of the game, they wouldn’t change anything, and they would play the game on a regular basis. Several users mentioned liking the sorting game the best, although a few also complained that it was too fast or too difficult. Two users compared aspects of our prototype to games they were familiar with. Decorating the hut was compared to a game called Math Rocket in which they put rocket components together before launching the rocket, and the sorting game was compared to a game called Math Bingo. The comparisons seemed positive; the users said these were games they enjoyed playing.

We clarified that after the users washed their hands and returned, the river shrunk in size (since many of the users did not pick up on this). We then asked the users to explain why they thought the river got smaller. Only two users correctly linked the river drying up to the water used for washing hands - one was the same user who was the only one to notice the decrease in water level after the hand washing. One user thought there might be a link between the river

sorting game and the water level of the river, and the rest seemed to just be guessing reasons why any river might dry up.

We then asked the users what they thought would happen in the game if they left the tap on all day after washing their hands. Three of seven said that the river or the island would dry up. Two other users mentioned changes in the game - one said the water from the tap would flood the island, and another said that you would lose points and the grass around the river would dry up. Only two out of seven didn't make any connection between leaving the faucet on all day and the state of the game.

We asked the users about ways they might like to decorate their coconut huts, but most of the answers were just variations on the items already present in the prototype. A few users mentioned other standard house features such as doors and chimneys. One user wanted to add pets to match the pets the user had at home. During a break between users, one of the teachers who had been observing the sessions suggested that customizing cars would be more engaging for one user in particular.

We also asked users how they might like to interact with other users' huts in the game. Many of the users seemed confused or hesitant about these questions, in which case we prompted them by asking if they would like to visit other users' huts or give gifts to other users that could be used to decorate. In retrospect this was a rather leading question, and most users simply agreed with those suggestions and didn't come up with any more on their own. One said she might like to watch her friends play the game at school rather than visit their huts in the game.

When asked what they do already to conserve water and other resources, the users gave a variety of answers such as turning off taps between uses, using fewer dishes to cut down on washing water, and recycling. One user said that she would try to keep her hands clean so she

wouldn't have to wash them, but that if they got dirty then she would have no choice but to wash them. This happened to hit on one of our biggest concerns while designing the game, which is how to encourage conserving water without encouraging poor hygiene.

Quantitative

The real-world sorting pretest and posttest had two purposes. The main purpose was evaluating the educational impact of the virtual sorting game - to what extent does the virtual sorting game teach participants how to sort empty cans and bottles before recycling in the real world. The secondary and closely related purpose is to evaluate how well participants are able to connect the virtual and real worlds. All the participants got the real-world sorting game correct on the first try, indicating that all participants had extensive prior knowledge of recycling materials. Therefore we did not get a chance to evaluate our game in this respect. We did, however, learn about the knowledge and skill level of our target population. We clearly underestimated their knowledge in this particular domain.

Three participants did improve their sorting times from the pre-test to the post-test. This is a positive sign for our game's success. However, four users did not improve their times from pretest to posttest. We noticed the main reason for this being that they were more cautious on the posttest and hence took more time.

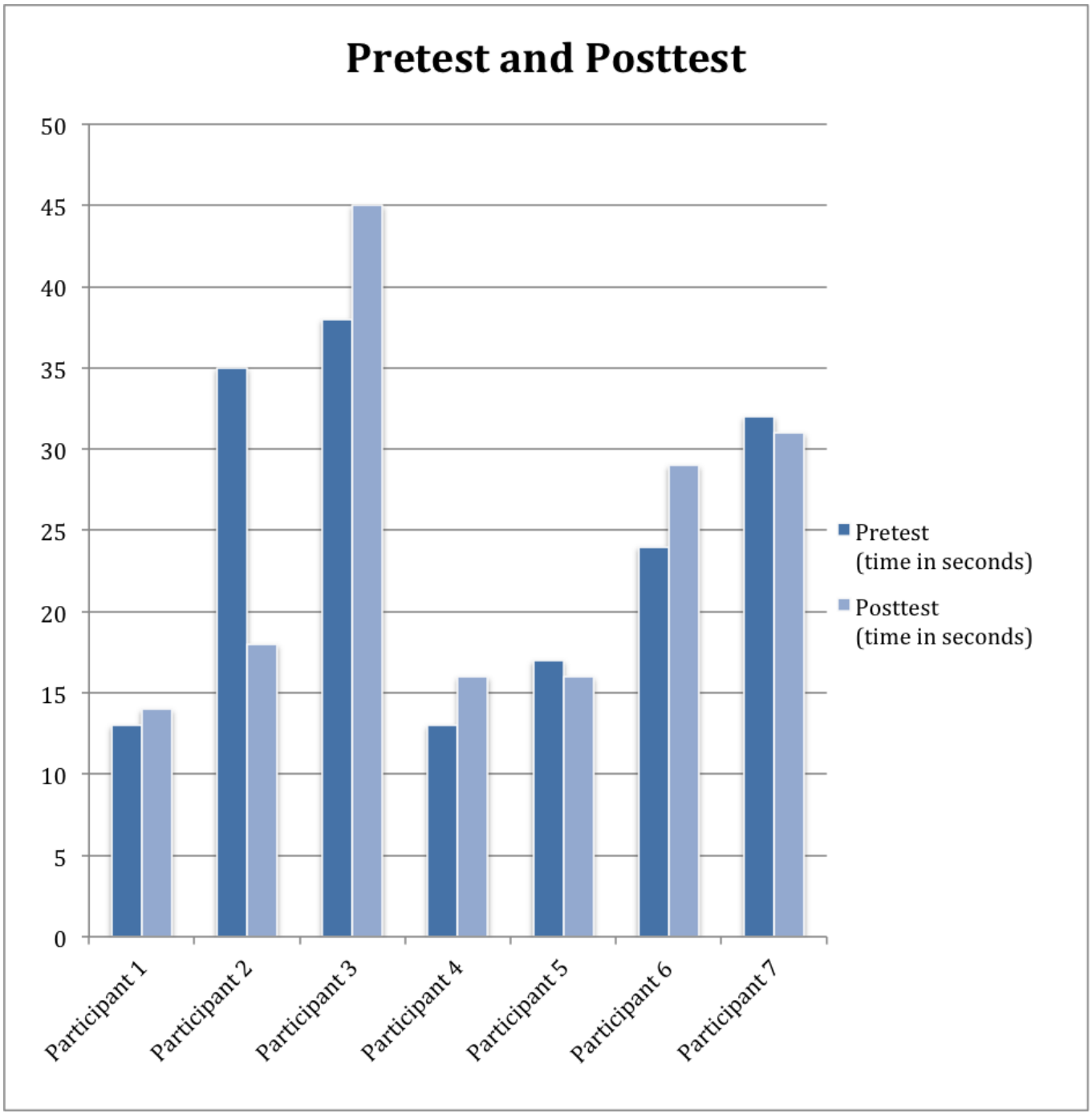

Figure 4: Pretest and Posttest Results

Most participants knew exactly what was expected of them when they saw the stream with bottles flowing down it. All the users commented on the speed of the bottles and cans, saying they were moving too fast. One participant mentioned that he liked the challenge.
A few children fumbled with the drag and drop mechanism initially. But once they figured out the interaction, did not have trouble getting the cans and bottles in the right bins.

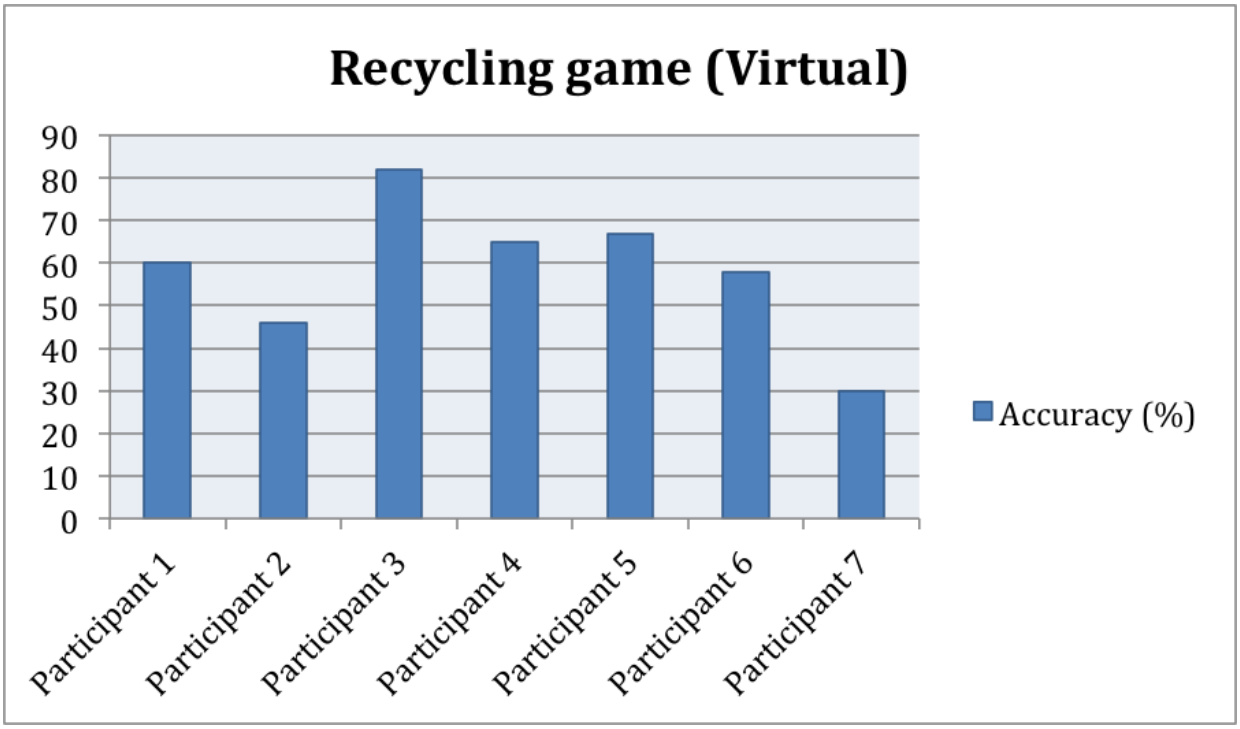

Figure 5: Virtual Recycling Accuracy

We asked the participants to all wash their hands and then gave them coins based on their times. HydroSense would finally drive this process, but for the purpose of testing we controlled the interface. Our presence watching them wash their hands and waiting for them to return seemed to influence their behavior. A few participants realized that the time they took to wash their hands would influence the game. This was a positive sign for us, but they may have reduced

washing time to an unhygienic level just to be proficient at the game. Other participants were not quite sure why they were asked to wash their hands.

Figure 6: Hand Washing Times

Discussion and Interpretation

Implications

The observation session of the participants using our resource conservation game, brought to our attention several issues in our design. The overall design of our game was well received, with participants describing it as *'fun'* and *'exciting'*, One participant did however comment on the *Coconut huts* in our game, stating *'I don't live in a hut',* which suggested a disconnect between their real world setting and those depicted in the game. Because the overall reaction was positive, the final design would remain in the cartoon-like, vivid style, depicting resource usage in an abstract manner.

The mini-game included in our prototype design, involves users having to sort different bottles and cans floating down a river into the appropriate recycling game (Figure 2). The mini-game is timed, with users provided points for sorting as many items as possible in a 30 second time limit. From all observation sessions, it was apparent that the pace of the mini-game was too quick for our target demographic. All participants missed at least 3 items, which would flow past as they were busy sorting another item. While the game was considered by fun by all participants, some did become slightly overwhelmed, others, particularly the older participants, did find the high pace a challenge. Our design was initially intended to be an iPad application, with touch gestures required to interact with game. The pace of the game may have been appropriate for this type of interaction, as making finger gestures require less precision. However due to technical difficulties, we had to demonstrate our prototype on a laptop computer. In future iterations of our design, we would include the ability to adjust the pace and level of challenge in the mini-games based on the user on any platform the game is presented. This would be done through users initially creating personal profiles for the game, which would include entering age information. Based on the age, a mini-game of an appropriate pace would be presented, with options given to increase or decrease the level of difficulty. All participants were able to categorize items that were flowing down the river. However, there was some hesitation between the glass bottle and plastic bottle from several participants, with one participant incorrectly sorting a glass bottle into the plastic bin. This suggests that the visual graphic of these two elements may be too similar to distinguish, and therefore may need to be redesigned to easier recognition.

The main interaction styles used in our game were point and click and drag and drop. As our prototype was presented on a computer, participants interacted with the games using a mouse.

During the observation sessions, we found that six out of the seven participants were able to correctly interact with the different features of the game. For example, in order to sort the items flowing in the river during the mini-game, participants clicked the item, and dragged them to the appropriate sorting bin. Also in the hut decorating screen, participants clicked and dragged into the decorations onto the hut. All participant received prior instructions about each stage of the game, however one participant did continue onto the next section (the sorting mini-game), before we were able to provide the instructions. It was this participant that we found, initially clicked the item then click the bin they wanted to sort the item into. This made us aware of the importance of prior instruction provided in the game in order to evoke correct interaction. Several participants had difficulty dragging the plastic bottle. This may be because the target size was too small, which would need to addressed in future development iterations.

The island river changes in order to reflect real-world water usage. The following states of the states of the river were shown to the participants in our game. Figure 1 was shown as the initial state of the island. Figure 2 was shown after the participants washed their hands.

Figure 7: Initial Island State

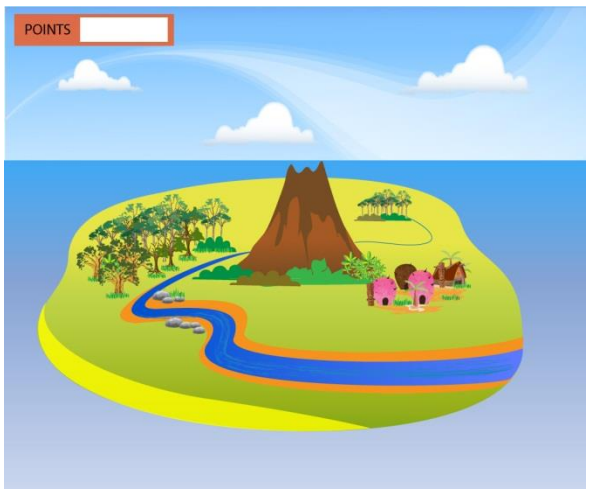

Figure 8: Post Washing Island State

We found that two of the participants were able to recognize a drop in water level in the river, as it was *"drying up"*. Three other participants were able to notice some change in states of the river, describing it as *"orange around the edges"*. The remaining two participants did not realize a change in states, with one of user stating that there was less grass around the river. We may need to make the change of states in the river more prominent, with an additional cue as a form of redundant coding to signify the change, such as sound effects. A full river could be accompanied by a gushing river sounds which decreases in amplitude as the water level changes. We did not consider red-green color blindness in users in our design, which may cause issues in differentiating between the orange river bank and the green grass. We would need some alternate color schemes that can be chosen in order to accommodate different types of color blindness.

Only two participants made the connection between the river drying up and their real-world water usage (hand washing). There are several possible explanations for this. Perhaps this is due to insufficient explanation of this connection at the beginning of the game. Perhaps it is due to the limited scope of our prototype and the limited time participants spent interacting with it. Had we included electricity usage as well, or had participants been able to use our prototype over time, the connection might have been clearer. In addition, since only two participants noticed a change in the water level, it seems likely that this contributed to participants failing to make a connection between real-world actions. In the next section we discuss changes we can make to address all of these problems.

We observed a mixed reaction to decoration of coconut huts as an incentive. While some participants were enthusiastic about decorating, interacted with the pets, and suggested novel decorations, other participants made only cursory comments about decoration and did not interact with pets. This suggests (as we had considered previously but did not have time to

implement) that we should include different types of in-game personal belongings to customize. This was reinforced by a suggestion from teacher who observed some of participant sessions. After a participant who did not show much interest in decorating the coconut huts or visiting friends' huts had left, the teacher mentioned that customizing cars might be a more engaging incentive for the participant.

All the participants demonstrated a clear understanding of the topic of recycling during the real-world sorting exercises, thus had no trouble performing the sorting mini-game of Eco Island. We felt that our choice of virtual activity did not provide the educational experience we were striving to create, as the students already displayed a mastery of the topic. This impacted the ability to measure the level of effective knowledge transfer of our system. If we had provided activities with content that students were not as familiar with, and then tested their understanding after interacting with our system, the measurements would be more accurate. The implication of this issue to our design is that we need to include a wide range of activities that cater to the different knowledge levels of our target demographics.

Changes Made

Interaction

The initial prototype was a series of static images with clickable hotspots to progress through the scenario. As we watched our peers in CS 6750 interact with the early prototype, we were told repeatedly that we needed to add some interaction and animation to make the experience more engaging for young children. To achieve this, we added clickable objects whose sole purpose is to make the experience more interesting. We also added more hotspots to allow the user to revisit previous scenes in order to reinforce their content. For example, after the user

decorates her hut, she can return to the island overview screen to observe any further water usage updates.

Figure 9: Hut Without Pet

Figure 10: Hut With Pet

Visibility

One challenge involving visibility was how to make changes to the river level evident without exaggerating the impact of the resource usage. In our initial testing, users did not even notice that the level had changed unless we pointed it out to them. To make the change more evident, we lowered the level of the water further after the user had completed the evaluation task. It is clear that we needed to make this change more noticeable to cross the threshold over user awareness, but we still have concerns that we might have lowered the level too much. We will continue to update the graphics in further iterations of the design.

Figure 11: Original Low Water River

Figure 12: Updated Low Water River

Affordances

When we originally designed the system, we tried to make it very clear what actions were available by styling many clickable hotspots as buttons. However, during our formative evaluation of the prototype, some users were concerned that children would not know what they could click on based on the current artwork. It was suggested that we apply a subtle glow to clickable objects to give the users a hint about which items they can interact with. When we evaluated the prototype with actual users, they did not seem to have a problem discovering the affordances of the system with the newly styled artwork.

Proposed Changes

During our observation sessions, we provided verbal explanations to the children at each step of the game. When they entered the game and reached the overall island, we gave them an overview of the game and its objectives. This was also done before the mini-game was initiated. Had we had more time we would have created a tutorial embedded into our design. We had made plans to include a guide in the game, for example a toucan with speech bubbles that would

provide the instructions of the game. In response to confusion about the connection between real-world actions and the state of the island in the game, we would include an explicit explanation of this concept, and perhaps a demonstration of the changes that will occur. Also we would include animated demonstrations of the mini-games, to show the methods of interaction required. This would eliminate any confusion regarding how to play the game, as well as create less bias in our user evaluation as all participants will be receiving the same instructions. The observation sessions saw some of the participants progress onto the next stage of the game, without allowing us to complete our instructions beforehand, which affected the manner in which they interacted in the following stages.

Another change we would make if we had more time is to include varying states of the volcano to reflect electricity usage. Currently our system only shows water usage, through differing states of the river on Eco Island. Adding electricity usage display may help reinforce the connection to real-world actions. However, this may prove to be more challenging as the electricity usage is not as explicitly controllable by the user as water usage.

Based on our evaluation feedback there are several small design changes that we could make on future iterations. These include making the changing states of the river more prominent, changing the pace of the mini-game, and including more decoration pieces for the Coconut huts. Ideally, we would have liked to gathered user feedback from each iteration of our prototype however, due to time constraints, this was not possible.

Reflections

UI Design

Our group was initially hesitant to spend such a long time in the design phase of the system. We knew that there was a lot of work to be done in the upcoming building and

evaluation phases. We thought that designing a system that directly linked resource usage to each appliance would be the best way to teach children about where they can improve their usage consumption. However, after talking to teachers of our targeted age group, we realized that it is very different designing for kids than designing for adults. We changed our goal from implementing an interface that directly displayed relevant data to a more abstract, whimsical interpretation of the data that could hold kids' attention.

The first round of interviews changed the concept behind our system. However, once we had our initial prototype, we were once again given feedback that substantially changed our approach to the game. Feedback from peers and children suggested that the experience was too static for children. This caused us to add animations to several of the objects, and to make others respond to clicks by curious children.

We also considered the framework outlined by Don Norman. First, we considered the visibility of our system. We wanted to make sure that kids could quickly discern the state of their resource usage, and that the possible actions in system were easy to see and act upon. To increase the interaction of the system, we added an activity where children can decorate their own coconut huts based upon coins earned in the game. We also gave each child an animal companion next to her hut that provides visual and auditory feedback when the user clicks on the animal (or touches it when displayed on the iPad).

Project Teamwork

Our team worked efficiently together throughout the semester because of our complementary skill sets. Zuiena, Dustin, and Nitya are all on the MS-HCI CS track. They were able to quickly prototype systems based on our design alternatives. Andrew, coming from a psychology background, was integral to the development of the evaluation procedure. We

learned that it is best to meet to discuss high-level strategy, and then separate to implement the separate parts of the project. For example, after deciding on our final design, Andrew and Zuiena set to work on the artwork for the game, while Dustin and Nitya began developing the logic to implement our design decisions. The group then came back together at the end to synthesize our results for the report. This system worked well throughout the entirety of the project.

What We Would Do Differently

If we had to start over, we would have liked to spend more time iterating through our approach to the final design. We spent a lot of time developing three alternatives. We integrated elements from each of these into the final design. However, once the design was chosen, further updates were mainly superficial due to time constraints. We are happy with the design, however it is possible that further iteration may have increased the fun factor of the game.

Another area for improvement would be increased interaction with the users of the system throughout the development of the game. We talked to teachers early on and their feedback was crucial to our final design. However, we were not able to talk to children until much later as we waited for feedback from the Institutional Review Board. After finally getting a chance to show the system to several children at a local elementary school, we realized that more frequent interaction may have allowed us to make changes to the game early on before the prototype was implemented.

Group Member Responsibilities

The beginning of the evaluation phase requires all group members to work together to develop a testing plan. All four group members were present when we decided which age group we were going to study, the tasks necessary to evaluate the system, and what types of data we hoped to collect during the evaluation. Once these decisions were made, Dustin and Andrew

worked together to develop the documents necessary for submission to the Institutional Review Board. This included the interview protocol as well as the consent and assent forms for both parents and children to sign.

In February, Dustin and Zuiena forged a partnership with a local elementary school to receive feedback on both our initial designs and then evaluate the prototype. Dustin and Zuiena conducted formative interviews with teachers to get a better idea of what types of games would be appropriate for children in each grade level. Dustin then reached out to the 1st, 2nd, and 3rd grade class to see if we could evaluate the system using children in this class. Andrew, Zuiena, and Nitya traveled back to the school to interview the children. They each shared the tasks of asking the children questions and collecting notes during each others' interviews. Finally, the whole group met to compile observations and determine what the results of the evaluation meant in terms of further improvements to the system.

With the results of the evaluation compiled, we were able to divide the final paper so that each member could write about an area where they put in considerable effort. Once the report was finished and each member had reviewed it, we had a strong understanding of the message we wanted to convey in our final presentation. This allowed us to efficiently create the final presentation based on a shared vision of how this project was developed, and what opportunities we found for improvement in further iterations.