Online Kidsteam: Developing an Environment for Geographically Distributed, Intergenerational Participatory Design

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ABSTRACT

As more children's technologies are designed to be used with a global audience, new tools need to be created to include more children's voices in the design process. However, working with those children who are geographically distributed as design partners is difficult because existing technologies either do not support distributed design, or are not child-friendly. In this paper, we describe the design process of an online environment to support geographically distributed, intergenerational participatory design. Within this environment, children can work together despite differences of time zones, geographic location, or availability. The online environment was deployed for eight weeks during the summer and was modified each week throughout that time to better support the participants. Observations, activity logs, design artifacts, and interviews informed the iterative design of the environment. For the first six weeks, participants were located throughout the United States and accessed the environment when they wanted from where they wanted. In the final two weeks, some participants accessed the environment while co-located and other participants continued to participate from their own locations in other time zones. Based on the experiences of participants within the environment, we make suggestions for new technologies including user management tools, creative expression tools, and ad hoc team membership including a novel way for co-located users to log in and collaborate on the same computer.

Categories and Subject Descriptors

D.2.2 Design Tools and Techniques: Evolutionary Prototyping

General Terms

Design

Keywords

Children, Design, Participatory Design, Cooperative Inquiry, Distributed, Environment

1. Introduction

As more children's technologies are designed to be used with a global audience, new tools need to be created to include more children's voices in the design process. However, working with those children who are geographically distributed as design partners is difficult because existing technologies do not support this process, do not enable distributed design, or are not child-friendly. In this paper, the authors take a Research through Design approach to develop an online environment that enables geographically distributed, intergenerational co-operative design.

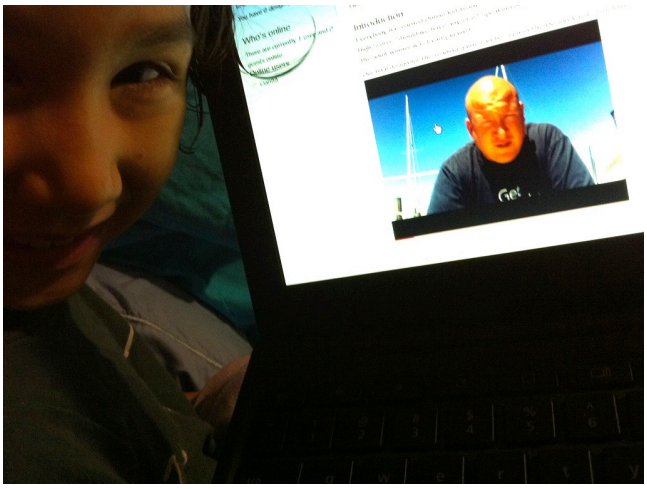

Figure 1 - A child participant showing the online environment.

Within this environment, children can work together despite differences of time zones, geographic location, or availability.

The need to work with geographically distributed co-design partners is a real-world problem. The International Children's Digital Library [7] was designed by children around the world and required heavily modified techniques to succeed [2]. As another example, Carnegie Hall's Weil Institute of Music was interested in distributed co-design in order to improve one of its programs [21] but had difficulty due to the time-zone differences. The children in the program could not work on prototypes together because of time zone differences as one group was in New York City and the other group was in New Delhi, India.

In order to help alleviate problems such as these, the authors developed an online environment to enable geographically distributed, intergenerational co-design. The environment established in this work is important because the distributed co-design technologies not only enable distributed design, but they also enable new kinds of co-located co-design techniques as well as support in-person high-tech prototyping in the traditionally low-tech prototype realm of participatory design. These contributions can lead to underserved and hard-to-serve populations participating in the co-design process by giving a voice to those who, frequently, cannot participate in the design process of technology due to location, availability, or access to transportation.

The goal of this research was to determine: How can co-located, cooperative design with children and adults be translated to an online environment that supports geographically distributed users?

This paper is presented as a design narrative in order to provide the reader with a week-by-week account of the experimental design environment and is organized by overarching themes that evolved from the experiences of the children and researchers. At the end of the paper, we discuss lessons learned and make suggestions for technologies that should be considered when developing online, collaborative environments for children.

This paper has no p-values, no means, no standard deviations, nor charts on access times or usability metrics. Although this project involved one previous reported up technology, it is not about one cog in a complex machine. This research was the start of new ways to give a voice to people who do not often have a voice in the design process. It was as much about the participants (adults and children) and their place in the environment as it was about the technologies, both new and existing, implemented. It is new and odd and may challenge beliefs in usefulness but nonetheless, it is important.

2. Related Work

Because the potential audience for this research is so varied, we present a summary of the diverse fields that make up this work: children and HCI, participatory design, computer-supported cooperative work, and design research.

2.1 Children and Participatory Design

Children have been involved in various aspects of the technology design process. They have been users, testers, informants [15] and design partners [3]. These roles enable children to participate at varying stages throughout the design process or through the whole process. At the same time, these roles enable design researchers to illicit feedback from children or work with them as full-partners in the cooperative design (co-design) of new technologies. In Druin's Cooperative Inquiry, children and adults work together to design new technologies for children as design partners [1]. The instantiation of Cooperative Inquiry is Kidsteam.

In Kidsteam, children and adults collaboratively build low-tech prototypes at different points in a design's lifecycle in order to elicit requirements and provide new directions for the designs to explore. Children between the ages of 7 and 11 join Kidsteam for one school-year as design partners and work with adult researchers and outside organizations in the design of new children's technologies. The team is comprised of six to eight children and four to six adults and they meet twice a week after school for their design sessions.

A typical Kidsteam design session consists of four sub-sections: Snack Time, Circle Time, Design Time, and Big Ideas. During Snack Time, children and adults share a small snack and are free to discuss whatever is on their minds. In Circle Time, the design group sits in a circle and answers a Question of the Day that pertains to the topic that the group will work on during that Design Time session. In Design Time, the team uses techniques, creative endeavors that are meant to communicate design ideas and system requirements to the larger group [19]. At the end of the session, the group gets together and discusses the Big Ideas, which become the design requirements for future iterations of the technology designed in that session.

Some popular techniques include Stickies, Bags of Stuff, and Layered Elaboration. In Stickies [1], design partners look at new technologies and express their likes, dislikes, and design ideas on individual sticky notes which are organized and sorted in a common area of the design space. Bags of Stuff [1] are large plastic bags of art supplies that are used to build low-tech and low-fidelity prototypes. In Layered Elaboration [20], design partners express ideas in drawings and are elaborated upon by adding transparent sheets of plastic so that other designers can draw on top of the design without destroying the original.

Traditionally, these design sessions have been co-located, meaning taking place at the same time in the same place. Because the sessions are co-located, the diversity of their membership is dependent upon those that are able to physically attend a pre-arranged location.

2.2 CSCW and Design

Computer-supported Cooperative Work (CSCW) is "an endeavor to understand the nature and requirements of cooperative work with the objective of designing computer-based technologies for cooperative work arrangements" [16]. It is difficult to discuss distributed participatory design before understanding distributed design within a CSCW context.

Rodden and Blair [13] describe that CSCW technologies take place over two dimensions: form of cooperation and geographical nature. The forms of cooperation deal with the temporal aspects of collaborative work as being synchronous, asynchronous, or mixed. In this case, synchronous means work is done at the same time and asynchronous means that work is done at different times by team members. The geographical nature dimension describes where the participants are in relation to each other.

Saad and Maher [14] investigated the role of CSCW in distributed design. They found that collaborative design required more complex interactions and information than other types of collaborative work. Other researchers have investigated the use of collaborative technologies through developing a tool call Slice and observing a geographically distributed team in the design of a rocket engine that cost less than traditional solutions [12]. In the TeamSCOPE [8] project, a project that relied on distributed design, researchers determined that a number of tools were necessary to help create a centralized place for distributed teams to keep their designs.

In all of these previously mentioned projects, the main users of the systems were experts. These experts were engineers or professional designers whose jobs depended on collaborating with other professionals. In terms of participatory design, the lack of involvement of end-users is a shortcoming in this work. However, these projects are all extremely important in the context of geographically distributed participatory design because they set the stage for future projects and provide guidance into the types of technologies and frameworks that would be necessary for distributed collaboration.

2.3 Design Research

Horvath [6] described three types of design research: research in design contexts, design inclusive research, and practice-based design research. In research in design contexts, scientific principles are applied toward design inquiries. Techniques from different scientific fields, such as psychology, information studies, or ergonomics are used in the generation of knowledge. In this context, the knowledge gained from utilizing specific designs in research can lead to better insights and the development of new theories. In practice-based design research, those that led or

participated reflect upon an existing project and theory and knowledge are based upon that reflection.

Design inclusive research is a methodology framework in which design becomes a vehicle for research. The context is less theoretical than the research in design contexts methodology and seeks to create knowledge by generating prototypes. The goals and contexts of this methodology are similar to Research through Design (RtD) [22] in which researchers' prototypes are informed by outside disciplines in order to generate knowledge. Design by research should lead to the identification of a concrete problem and an ideal state that solves the problem. RtD is useful because it provides a lens for those investigating the design processes of different kinds of technologies, including children's technologies. An example of RtD was the development of the reverse alarm clock [10] which was a new way to help children understand when it was acceptable to get out of bed.

3. Method

3.1 Sessions Structure

The research goal was to develop a set of technologies to support distributed co-design, enabling children in different physical locations to design technologies together. In order to solve this problem within the framework of design inclusive research and research through design, the authors created a web-based Online Kidsteam as their embedded prototype that an intergenerational team used over an eight-week period. During this time period, the team's use of the environment informed weekly design changes. Instead of regular meeting times, Online Kidsteam members logged on to the website and participated in design sessions from when and where they wanted for the first six weeks and for the remaining two weeks in a mixed environment where some participants interacted as a group in a lab and another group participated in the same activities as individuals from their homes.

The distributed design activities started as online representations of the sub-sections of typical Cooperative Inquiry sessions at the beginning of the research and were iteratively modified and evolved as the experience unfolded. As mentioned, the original co-located, co-design team agenda was: Snack time, Circle time, Design time, and Big Ideas. The distributed co-design team in the online environment had modified versions of these agenda items that replicated their core functions based on the initial understanding of them.

3.1.1 Completely Asynchronous Co-Design

In the first six weeks, adult and child participants connected to the online environment at their convenience. Most weeks had an introductory video from an adult researcher to the design team explaining the design challenges for the week on a home screen that had links to the different sections, or modules, of the environment. Each module corresponded to a part of a typical Kidsteam session, for example, a chat room to represent Snack Time where informal discussions took place, and these are further described below. There was no set way in which the design team was asked to interact with the modules, despite the typical session agenda usually engaged in during a synchronous collocated session. The only limitation to when and what order the tools could be used was that as a participant used the design module, it became locked so that others could not edit the same design until the active participant signed out.

During this period, the design team worked on the following design problems: vacation of the future (Week 1), photography web site for children (Week 2), Online Kidsteam itself (Weeks 3 and 6), and a video game to help young children learn to read (Weeks 4 and 5). See Table 1 for descriptions of the weekly topics.

3.1.2 Mixed Synchronous and Asynchronous Co-Design

In the last two weeks of the research period, the environment was used as part of two in-person Kidsteam sessions that each extended for one week in the online environment. Instead of all of the participants connecting when and from where they wanted, some participants designed in co-located groups while other continued using the tool as before.

Table 1 - Design Challenges and Select Changes to the Environment by Week

Week	Design Challenge	Select Environment Design Changes
1	Vacation of the Future	In-environment messaging Improved back-end workflow to prevent lost data and lock outs Reformat the time and date in Snack Time postings Add avatars to the Snack Time module List of participants Improved navigation Improved tools for co-located design from one computer.
2	Photo Sharing Site	Functionality to increase motivation
3	Online Kidsteam	The need for audio in the design session The need for a motivator and explicit instructions for the children through video Incorporating live communication Bringing three-dimensional design tools and interaction to the design area
4	Reading Game for Children	Simplify audio recording steps for all ages
5	Reading Game for Children – Likes, Dislikes, and Design Ideas	Create specific functionality for capturing likes, dislikes, and design ideas Create functionality for visualizing the likes, dislikes, and design ideas Add more objects to the e-Bags of Stuff Allow system to update the design space while someone else is editing.

6	e-Bags of Stuff	Rotating and translation need to be implemented for objects that are representations of three-dimensional objects More art and craft items for designers to choose from.

3.2 Participants

The research was broken up into two sessions: one six-week session where participants were at a place of their choosing and used the system as they wanted and one two-week session where the environment was used as a part of face-to-face Kidsteam "Camp". In the first session, there were 12 child participants with ages ranging from 7 to 11 (M= 8.92, N = 12, SD= 1.44) and 9 adult participants ranging in age from 20 to 48 (M=32, N =10, SD=8.63). There were six boys, six girls, seven female researchers, and three male researchers. In the second session, there were an additional three girls and two boys who participated (M =9.18, N = 17, SD=1.33) in the co-located environment while seven children only participated from their own location. All but two of the child participants were or had been members of Kidsteam.

3.3 Data Collection and Technologies

Each week, the design process was documented in a research journal in three ways: a summary of the week, ideas about the environment that were generated from that week, and an attempt to reframe the problem based on the previous two items. Also used as data for this project were parental communications, interviews, and artifacts generated during each week's design sessions.

Online Kidsteam required a suite of tools to enable participants to design in the distributed environment. The four previously mentioned sub-sections (Snack time, Circle time, Design time, and Big Ideas) were used as the original framework for the tools. The tools were built with a combination of Drupal, PHP, JavaScript, HTML, MySQL and Adobe Flex.

Drupal is a content management system for Web sites [4]. It has many built-in features to support sites with members: login and password management, profile pages, avatars, and roles. Additions, known as modules, are created by the community and allow for extended features like chat rooms and forums.

HTML is "the publishing language of the World Wide Web" [17]. It is a mark-up language that enables developers to display text, graphics, interactive elements, and forms in a Web browser. By itself, HTML offers limited opportunities for interactivity and is often paired with JavaScript.

JavaScript is an interpreted language that operates in modern Web browsers [5]. JavaScript is able to communicate with HTML elements to retrieve and set values. It is useful because it enables embedded objects to communicate with other objects on the Web page.

PHP is an embedded scripting language for Web development [11]. Developers place code into the web page that is converted on the server side and returned as plain HTML. PHP is often used when developers want to extract or input information into a database.

MySQL is an open source, structured query language compatible, relational database [9]. It is often used in conjunction with PHP as a database for Web-based applications. It can store text and binary objects and was well suited for this project.

Flex is an open source variant of Adobe Flash. Its language is similar to Java and was designed to aid in the development of Web-based applications. Conversely, Flash was designed as an animation tool although it has been used as a development platform. Flex is compiled into a Shockwave Flash File, or SWF, and embedded as an object within an HTML page. SWFs can communicate with HTML objects through JavaScript. The use of Flex and the AWave MP3 library enabled a web-based application for recording audio. This functionality has traditionally been difficult in Web-based tools. With the addition of this component, asynchronous notation through voice was possible.

These technologies are important to note because of the benefits and limitations they presented to the research team. On one hand, the use of Flex provided tools and technologies to rapidly create sophisticated online design tools including the capability to record audio. Conversely, using Flex and, by extension, Flash, participants were unable to use the online tools with iOS based devices like the iPad (More on this in the discussion section).

4. Findings

4.1 Distributed Co-design Sessions

4.1.1 Initial Design Directions

The first version of the environment began with an existing version of a tool designed for intergenerational design called DisCo [18], an electronic whiteboard designed for asynchronous design, combined with a Drupal content management system to support online cooperation. This was a basic version of the environment and it soon became apparent that the nature of distributed design would show that this configuration was inadequate. The design challenge for the first week was to create a vacation of the future.

At the end of Week 1's design session, the participants wanted social interactions in ways that hadn't been anticipated. Participants wanted the addition of avatars and a list of participants to create a sense of physical presence that was lacking in the online environment. Also, making the environment more child-friendly by changing the formats from the default settings of time and date was a recommendation resulting from the session. In Week 2, several parents contacted the authors to let us know that the screen was too big for small laptops. Due to the non-scaling nature of DisCo, the tool was being cut off on small laptops such as the MacBook Air and the Intel Classmate PC.

In the previous week, the authors noticed that only one of the child participants actually added to the design prior to an adult contributing. In order to investigate this observation, the adults were asked to not participate in the design sessions for the first few days to give the children a chance to initiate designs, and surprisingly, no child participants did. The adults were then prompted to participate. Consequently, two of the children added their ideas to several of the designs. The lack of participation in the design module on the part of the children was contrasting to the participation in the Snack time and Circle time modules. The low levels of participation within the design module led to the addition of a motivation system for all module activities.

In Week 3, the authors added functionality to the online environment that gave points for various actions on the site to increase motivation. The design activities gave the most points and the most popular activity, Snack Time, would give no points. There would be two rewards: the top point earner per week would

be congratulated on the home page and awarded a virtual badge that appeared with his or her avatar. Any participant would be able to directly message another member if he or she scored a low entry level of points.

During Week 3, the authors received emails from two parents about the environment. Both suggested that the typing required by the environment was extremely difficult for younger participants and the parents were typing for the children. The parents also mentioned that the design activities were too abstract for their younger children. One parent stated that his child thought it wasn't as fun as the face-to-face Kidsteam because it was asynchronous and another parent thought the entire site relied too heavily on words and suggested using pictures and video for instructions. Although the authors had used videos in weeks one and two, they did not use them in week three, and this had proved to be problematic for some of the participants.

The topic for week 3 was helping to design the Online Kidsteam environment to better suit participants. The weekly design challenge was broken up into three sub-challenges: tools to help participants communicate with each other while designing, tools to design within the environment, and tools to help participants develop new technologies instead of merely designing them. For example, participants would have tools to develop software from their designs.

Most of the ideas for communicating with other participants while designing were focused on synchronous communication. There were suggestions for both audio and visual communication, as well as the novel idea of using three-dimensional technologies to communicate with other participants through their television. One participant did think about the problem of communicating with other participants asynchronously. In her design, there would be a space separate from the design area that participants could use to plan and discuss their ideas before adding them to the main design module. This suggestion is interesting because the design area was intended to act as a work area to describe and iterate on ideas. This is not unlike previous findings that children are less forgiving of what they create with a computer than what they build with arts supplies [18].

The ideas from Week 3 for new ways to design were centered on improvements to the existing environment and novel interaction design. One participant wanted three-dimensional images to appear over real objects while designing. For example, when designing a new shoe, the designer could overlay the mock-up over his real foot. Another participant wanted a projector and touchscreen interface, while another participant wanted clay that could be shaped into objects on the screen and then a finished version would appear.

Because Week 3 was self-reflective on the design environment, there were many ideas generated to improve the Online Kidsteam experience for participants, including the ideas generated through analysis of the parental communications: the need for audio in the design session, the need for a motivation system and explicit instructions for the children through video, incorporating live communication, developing a scratch pad functionality to enable refining designs before placing them into the main design area to enable more creative expression, bringing three-dimensional design tools and interaction to the design area, reducing ambiguity in the design prompts in order to reduce confusion from the participants.

4.1.2 New Tools for Expression

In week 4, the design team returned to designing new technologies for children. The topic of the week was to design a video game that could help young children learn to read. The three sub-tasks were: What kind of game would children like to play?, what characters should be included?, and which stories should children read? In order to address the problem without the design challenges being too abstract, per the lessons from week 3, the authors posed the design sub-task as a question.

In this week, the authors added the ability for participants to record audio during Design Time. In order to simplify the design and make it easier for all participants to use, the authors added a large-sized audio recording tool in the shape of a red button to the area where the designers write about their ideas. The designers could then speak their ideas into a microphone and the system captured, encoded the audio into an MP3, and uploaded the audio file to the server. The system required designers to either write in the text box or record audio to describe their contribution.

When another designer came to the design module area after a previous participant/designer recorded audio, the timeline of comments would display a standard play button instead of text. In order to demonstrate this feature to participants, one author made an audio recording for each sub-task prompting and describing the activity.

To address the design idea from Week 3 of using video as instruction and as a motivator to contribute to the online environment, one author recorded a video in which he recapped the previous week's design idea and then described what the group would be doing this week (See Figure 1). He described the background on the challenge and announced the last week's high scorer. In the video, he also gave instructions on how to use the play and record buttons and reminded the group about scoring points. In this way, the design prompt and the new feature were introduced to the participants using two modalities to ensure that the new feature could be easily used and that the design prompt was clear.

There were some problems with the audio tool during week 4 and subsequent weeks. In order to record audio through Flash (through any browser-based applet), the user must have their microphone correctly configured and grant the applet, in this case the Flash-file, permission to access the recording capabilities. This posed two problems that required some skill: configuring audio equipment settings and accessing Flash's permission tool. For the laptop users, there was little problem with configuring the audio settings as a microphone is often included. However, for those participants using machines without built-in microphones, the hardware and software set-up was sometimes difficult. Even if the participant had set up the hardware correctly, the software needed to be configured to work. There was at least one participant who tried to record but was unable to and the audio file attached in the comment section was blank.

During Week 4, it became apparent that there was an unforeseen limitation for younger participants. In synchronous Kidsteam, younger children (ages 7 and 8) work with older children (9 to 11) or adults to complete the design tasks. In an online environment, the younger participants were at a disadvantage if trying to accomplish the design challenges independently, as they often did not know how to overcome the technical challenges posed by their computer use.

4.1.3 New Design Tasks

In week 5, the design team had two design challenges. The first design challenge asked the participants to use the current Online Kidsteam tool to express their likes, dislikes and design ideas of the low-fidelity prototype of the children's reading game created based on the group's designs. In order to continue with the iterative design of the reading game, the design ideas from Week 4's design session were used to create a drawing of the game with a text description using actual paper, pencils, and crayons. Then, the authors took a digital photo of those drawings and inserted them into the Online Kidsteam environment canvas using the photo tool. In all previous weeks, participants had designed on a blank canvas, so this addition of their actual design represents not only a deviation from what the participants were used to, but also a step forward in the design of the reading game.

When this technique is used as an in-person activity, the design partners write one like, dislike, or design idea on a sticky note and place it on a surface. A member of the design team organizes the sticky notes into general commonalities, or trends, which draw the attention of the group to areas of the design that need improvement or that should remain the same. For the online activity, the authors asked the design team to only put one thought into the design tool and to preface the comment with the words "like", "dislike", or "design idea". The version locking functionality from the design tool was removed so that multiple people could be operating at once. This also enabled participants to easily post multiple comments by simply clicking the Back button in their browsers.

The participants posted their likes, dislikes, and design ideas. This resulted in 20 comments from 12 different participants. Some of the participants wrote their design ideas but then drew something to augment the mock-up. Both writing a design idea and then creating a drawing of the design idea is unique to the Online Kidsteam environment. There is no equivalent functionality when performing this activity in a synchronous session with paper materials. Instead, the Online Kidsteam environment enabled designers to augment the designs even during design stages of evaluation and critique.

Although this feedback generation tool worked well, there were problems that need to be addressed in future revisions based on the design artifacts. The back and forth required of participants to make multiple comments was tedious and there was no way to easily manipulate the likes, dislikes and design ideas into like groups for analysis as is done in synchronous sessions with paper artifacts.

The second challenge for Week 5 was to play with a reconfigured Online Kidsteam environment that used graphics of three-dimensional found objects such as cotton balls and toilet paper rolls. These graphics mimicked the tools and objects available in the low-tech prototyping activity called Bags of Stuff. By prompting participants to use this reconfigured Online Kidsteam environment, it was possible to expand the repertoire of design activities available within the environment. Up to this point, participants had only been able to mimic some of the synchronous Kidsteam design activities, such as providing feedback or generating two-dimensional drawings, and iterating on each other's designs. The addition of found object graphics attempted to mimic the use of the Bags of Stuff technique within the online environment. (See Figure 2).

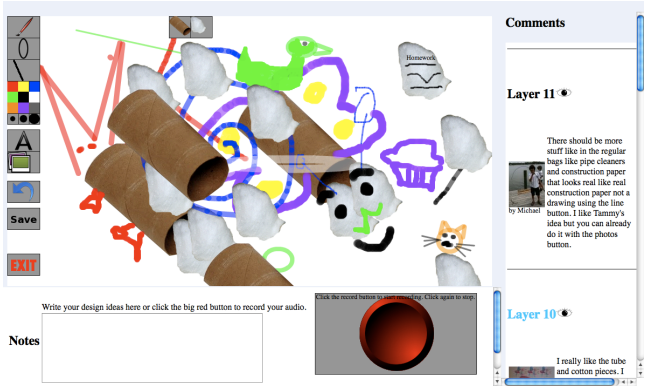

Figure 2 - Screenshot of Design Tool with Found Objects.

Week 5 was the first week in which the Online Kidsteam environment needed to be more than just an extension of Layered Elaboration [20] and instead move into a new direction by incorporating different design activities that do not exist in synchronous Kidsteam. It was also an example of how the online environment can surpass instead of mimic the paper-based methods on which it is based, as the participants were able to draw out their design ideas, which is not possible with the traditional feedback activity of likes, dislikes, and design ideas

Based on Week 5's design ideas, Week 6's topic was a new e-Bags of Stuff tool that included additional objects with which to design. Squares of virtual construction paper, pipe cleaners, and popsicle sticks were added to the toilet paper rolls and cotton balls. The pipe cleaners and popsicle sticks were each available in four different angles. When a designer used the pipe cleaner tool, the system randomly chose one of three colors. All the previously existing DisCo features were also available (drawing tools, etc).

The e-Bags of Stuff tool was still not well received by the

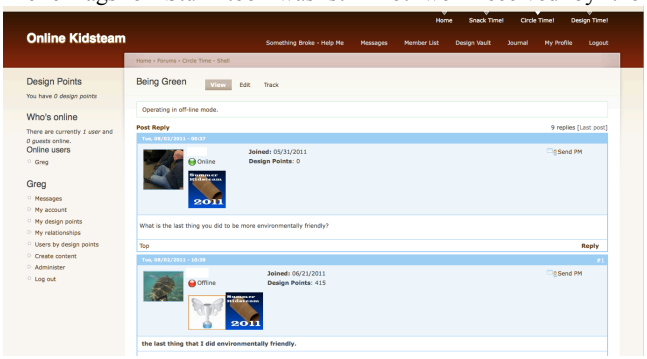

Figure 2 - Virtual Circle Time.

designers even after incorporating many of their suggestions while maintaining the same user interface as the previous DisCo tool. This was not surprising, as experiences with face-to-face Kidsteam have shown that Bags of Stuff is one of the favorite activities of the children. Much of the feedback involved the limitations of the two-dimensional graphics and the desire for true three-dimensional assets that are movable and can be rotated.

This week was also a lesson on the shortcomings of two-dimensional workspaces. The concept of Bags of Stuff did not work with the Online Kidsteam paradigm of flat layers and the two paradigms (three-dimensional objects and two-dimensional renderings on paper) are not compatible in this context. This problem may be due to the fact that there was already a positive attachment to Bags of Stuff because of in-person use that the child

designers did not enjoy the translation to in the online environment.

4.2 Co-located Design Sessions

4.2.1 Initial Co-location

In week 7, the Online Kidsteam environment was used in a different way than the previous six weeks. Instead of all of the participants connecting when and from where they wanted, some participants designed in co-located, intergenerational groups while other continued using the tool as before. Other changes included the entire co-located design team logging into Online Kidsteam and answered their questions of the week within the environment instead of partaking in a traditional Circle Time (See Figure 3). This was called virtual Circle Time.

Figure 3 - Children around a computer while accessing the online environment using the multi-person "clumping" login.

After virtual Circle Time, the children were split into three smaller groups made up of participants of Online Kidsteam, exclusively face-to-face Kidsteam members, and adult participants. The goal of the week was to design something to help more children be environmentally conscious at home, school, and while visiting the White House. The groups were assigned to the topics, given discreet amounts of time to design for one context (home, for example), and then were asked to move on to another design context (school, for example). This was repeated so that all of the groups were able to add to each of the design contexts. All of the design work was conducted within the Online Kidsteam environment, but some participants were synchronous and co-located. Using the online environment enabled non-co-located participants to elaborate on the designs created during these sessions as well. After the co-located group had finished, participants in remote locations were able to add to the designs as well. One participant in Online and face-to-face Kidsteam who was unable to attend this particular design session added her ideas to the three contexts at a later time.

In previous versions of the environment and the DisCo tool, only one person was credited with authorship if multiple designers were working on the same creation at the same computer. For example, if three participants sat together at the same computer and added their design to the environment, the only one that would be attributed in the notes section would be the one that was logged in. In order to prepare for co-located design work by some participants, a new author attribution system that allows multiple users to log in to the design tool was implemented, enabling multiple attributions. We call this a “Clumping” login because the

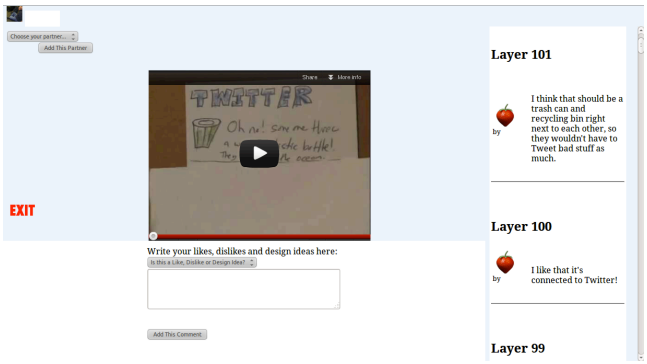

Figure 5 - Screenshot of the LaDDI tool.

phrase clumping is sometimes used in face-to-face Kidsteam to describe children gathering around one machine. (See Figure 4)

The problems previously experienced, such as difficulty typing or drawing, seemed as though they began to disappear in a synchronous multi-user environment.

4.2.2 A New Tool to Support a New Task

In Week 8 of using the Online Kidsteam Environment, the design team elaborated on the Week 7’s ideas by expressing their likes, dislikes, and design ideas about their designs for environmental stewardship in different contexts. This activity was similar to Week 5 and based on Week 5’s design ideas. A new tool was designed to be used within Online Kidsteam called LaDDI (laddie) that captured likes, dislikes, and design ideas and displayed them as virtual sticky notes to allow for clustering analysis.

Although the screen layout was based on the existing Design Time experience, there was a difference in functionality. The screen was divided into four sections: attribution, prototype, design section, and existing comments. The attribution section displays who is associated with this design session and enables users to add other co-located co-designers in the same way that DisCo does. The prototype section demonstrates the low-fidelity prototype being worked with. In the design section, participants can chose “Like”, “Dislike”, or “Design Idea” from a drop down menu and then fill in their idea. The existing comments section displays the feedback and design ideas from other participants (See Figure 5).

In order to organize the notes developed with the LaDDI tool, a second tool was designed that puts each of the pieces of feedback on to a virtual “sticky” note and arranges them in the order that they were entered. When all of the likes, dislikes, and design ideas have been entered into LaDDI, a designer can organize and lay them out in a virtual whiteboard to group the similar items. This enables designers to develop frequency counts of ideas and concepts in order to inform the next iteration of the design.

The entire group used the LaDDI tool to evaluate and expand upon the ideas generated by Week 7’s design session. After reviewing the “big ideas” generated in that design session, the authors developed a video animation of one of the ideas that was thought to be both novel and practical: a park-based smart recycling bin that sends a message through the Twitter service when it is used correctly and incorrectly. The video featured paper animations of the main features of the recycling bin while maintaining a feel that it was very easily changeable in order to encourage a design discourse.

The design partners were able to watch the video and then enter a like, dislike, or design idea. This was different than the workflow

used in week 5 because the LaDDI tool forced them to choose a category for their feedback. Also different from the previous version was the fact that the designers stayed on the same page after submitting their input and did not need to leave and re-enter the design tool in order to add a new idea.

The tool was successful in capturing many generated ideas for the next iteration of design. There were over 100 pieces of design feedback from the design partners who were both co-located and distributed, many more than in comparison to earlier weeks. In one case, one design partner displayed such high engagement that he worked in a co-located group during the lab-based activities and then went home to form another co-located group with his brother who was only participating in the online activities.

Many of the design partners were driven to earn points during this activity and asked clarifying questions to ensure they would receive points even if they continued to use the clumping login implemented the week before. Based on the author's journal, the level of engagement displayed by the design team using the LaDDI tool surpassed that of observed engagement during any traditional Kidsteam session in which the Likes, Dislikes, and Design Ideas technique was used

5. Discussion

The Research through Design framework combined with the Cooperative Inquiry method worked well in the iterative design of the geographically distributed co-design environment. Research through design contributed the iterative design through prototyping, while cooperative inquiry allowed the author a baseline of design activities from which to draw to the online environment. The iterative design of Online Kidsteam happened in three phases: the overall environment, the refinement of a major tool, and the development of additional tools to support the environment.

The first few weeks saw multiple changes to the overall environment from the original design. As previously mentioned, the environment was built with the content management tool Drupal combined with several pre-existing modules. Though one pre-existing module needed to be changed by adding avatar support, most of the environment changes were content-based, meaning creating additional content and tailoring the content to meet the needs of an intergenerational design team. The additional content was in the form of instructional videos, graphic badges, and new sections of the environment.

The Online Kidsteam environment went through major revisions during this project. New drawing tools, such as additional colors and e-Bags of Stuff, were added in order to support creative expression and to meet participant requests, as well as to allow for additional design activities within the environment. An audio tool was implemented, although not often used, in order to meet the needs of young design partners who have difficulty typing. A novel way for multiple design partners to indicate authorship for group designs was developed for the DisCo tool to support co-located group design that may occur in homes or dedicated design spaces.

In terms of additional tools, the LaDDI tool was added to the Online Kidsteam environment as a way to expand the kinds of design activities available in a distributed, asynchronous environment. By enabling small amounts of design ideas to be expressed quickly and easily, the number of ideas generated was increased to about five times those generated through the DisCo tool. The LaDDI tool also opens up new research opportunities with the field of Natural Language Processing and Machine Learning to develop visualization techniques and automated organization of the ideas.

5.1 Technology Recommendations

Based on analysis of each week's design session and interest in supporting both the co-design aspects as well as the positive experiences for children and adults, the authors have developed a list of functionalities that need to be included in an online environment to support geographically-distributed, intergenerational co-design. Some of these features were implemented throughout the development cycle of this work, but some participant problems were not identified until after the 8-week period had finished and those interviews led to the suggested design.

It is important to realize that some of these technologies are already present in cooperative technologies for adults but *are not present* in multi-user systems for children.

5.1.1 User Management

The system needs to maintain a database of users. The database stores information about each user including login and password, roles the user can perform, points the user has earned and awards that the user has achieved. Users can have a profile page, which is useful if members of the team are not familiar with other members as is likely for many projects with wide geographic distribution.

5.1.2 Cooperative Inquiry Session Structure

As previously mentioned, the system currently supports the method of Cooperative Inquiry by substituting online tools that replicate the sub-sections of an in-person session. Those sub-sections are currently: Snack Time, Circle Time, Design Time, and Big Ideas. However, the system should not necessarily use the same nomenclature. For example, Snack Time should become something more representative of the unstructured nature of that sub-section with a name such "Free Time". Circle Time can keep its name if the visualization is actually of members in a circle.

5.1.3 Creative Expression Tool

The current online environment supports creative expression through the DisCo and LaDDI tools. The existing tools enable intergenerational co-designers to create, elaborate, and evaluate designs from within the environment. Different designers and contexts will no doubt give rise to the need for new tools. These new tools need to be developed to enable participants to express their designs in ways that are fitting to the design space and maturity of the design problems.

5.1.4 Multi-Device Support

The most important technological requirement is the need to support Online Kidsteam on portable, tablet devices and not just on the traditional computer within a browser. Our users did not want to draw with the computer. Several times through the design sessions and in post-participation interviews, children mentioned that they wanted to draw with their finger on a touch screen device. Some parents also requested DisCo be usable on the iPad or iPhone because of the difficulty with recording audio on a traditional computer. Due to these reasons and the growing number of users of tablets and smartphones, the online environment should be available for multiple devices.

5.1.5 Design Forking

In in-person Kidsteam, the design partners are encouraged to create one solution per group, although that does not always happen. Instead, the individuals in each group sometimes create their own design and those designs are combined with others at the end to determine the requirements of the design. In Online

Kidsteam, creating an individual design was difficult.Some participants mentioned in the interviews that seeing others' designs made their work harder. One participant even wanted to be able to start from scratch. A system feature that allowed designers to "fork" the design or start with a blank canvas would be beneficial even though it has the possibility of stifling collaboration if each designer did this every time. A better solution would be to limit how often this act can be done through points or some other system. That way, forking a design would consume a resource and design partners would need to consider the benefits and costs of not being collaborative.

5.1.6 Ubiquitous Audio and Video Recording

Audio recording had the potential to help level the difficulties that younger design partners had with typing and mouse control while drawing. Some participants had expected the audio recording to be throughout the environment and not just in the design session. Also, participants had mentioned that they would like to have the option of recording videos for Snack Time and Circle Time instead of relying on text only. The system should support audio or video recording wherever there is a text input. This could alleviate some of the text input problems that participants had throughout the project.

5.1.7 Ad-hoc Intergenerational Design Teams

A challenge to overcome was the difference in design partners' abilities to communicate in an online tool and their ideas on what would help them to better communicate. The most logical conclusion to difficulty in typing would be to enable the designers to record their voices. As mentioned, this was added in the final prototype and was available for over two weeks of design sessions. But, very few participants took advantage of it. The adult participants only used it when asked to try it out and only two children used it. The prototype used the Adobe Flash Player, which enables audio recording once end-users make a change in their security settings—a change that required technical knowledge. Some parents and children took a decidedly low-tech approach and had a parent type for the child. We suggest that any type of intergenerational distributed co-design must be able to include the ability to add family members to the design team in either a formal or informal way in order to enable co-located design. Family members could be added to the design team through an informal, ad hoc mechanism that extends the clumping login by enabling new membership. In this way, participants can add family "on-the-fly" while creating a design. This way would be useful for including family members in the design team who do not want or cannot make the commitment to regularly participate. It could also be used as a way to include friends or introduce new members to Online Kidsteam.

5.1.8 In-Environment Tracking, Communication, and Synchronous Design

Although the asynchronous nature of the design environment exists in order to accomplish the goals of geographically distributed audiences, it would be best to support real-time communication between those participants who are on at the same time. In order to accomplish this, there needs to be reporting of who is online and "where" they are in the environment. The system currently lets users know if others are online but it doesn't display a way to contact specific users in real-time.

To accomplish this, the online environment would present all users with a list of other users logged in and the module of the environment that each one is interacting with at that time. The location would be important in case users wanted to participate in the same section as other designers concurrently. Participants would be able to click on a name and message that user in real-time.

Communication between adult researchers and child-designers would also occur within the design environment due to the lack of e-mail addresses for the child participants. Participants would be able to define some other contact medium, for example a parent's email or phone number with text messaging, that the environment could push messages to as events happen or other users try to contact them.

The final requirement that the online environment needs to satisfy is the ability for all design partners to synchronously design regardless of geographic location. Synchronous co-design is not mutually exclusive from distributed co-design and scenarios where distributed intergenerational co-designers in adjoining time-zones working with intergenerational co-designers in geographical areas several time-zones away are foreseeable. In this scenario, the designers in adjoining time-zones could synchronously work together and then designers in a different time-zone could add to those designs at a later time by synchronously working together amongst themselves regardless if they are co-located or not. *We call this co-synchronous co-design*. In co-synchronous co-design, the online environment supports asynchronous co-design through a persistent design area that also enables synchronous design. This is not dissimilar to the way the tool was used in the last two weeks of Online Kidsteam except that the synchronous designers were co-located. Co-synchronous co-design extends Rodden and Blair's ideas of synchronous, asynchronous, and mixed states of cooperation by more explicitly describing the elements of the "mixed" cooperative state and what kinds of activities are being included in this mix.

6. Limitations

The Participatory Design method employed throughout the research period was Cooperative Inquiry. In Cooperative Inquiry, children and adults work together as partners in the design of new technologies for children. Because this method was used as the basis for the online tools and techniques during this study, other methods that are used to gather requirements for children's technologies may not work with the online environment without heavy modification.

The timeframe for this research was eight weeks in the summer. Of the eight weeks, six of those weeks tried to replicate the in-person Kidsteam experience within the online environment and two of the weeks tried to augment in-person Kidsteam with Online Kidsteam. This time period was relatively short compared to other Cooperative Inquiry instantiations. In-person Kidsteam takes place twice a week over one academic school year. The shorter time frame for Online Kidsteam was necessary to enable participation in the summer when the child participants were not in school and to not interfere with in-person Kidsteam's schedule.

Ten of the twelve child participants of Online Kidsteam had participated in in-person Kidsteam at one point in time. Experience with Kidsteam methods was necessary to work within the time frame available. As all the participants were familiar with the Kidsteam model, it is impossible to tell if the design environment would be applicable and approachable to all children without modification and tutorials.

7. Future Work & Conclusion

This research has just scratched the surface of geographically distributed, intergenerational co-design. Including more voices into any design process is extremely important, and as more

projects involving children become international and global in reach, which is extremely important to Child-Computer Interaction. There are a number of future projects that stem from this work including: implementing a co-synchronous design tool with several different intergenerational design teams, maintaining a long-term distributed design team, and exploring the experiences that children have while participating in this kind of environment.

In this project, the authors developed a tool and tested the tool with a group of experienced designers. Iterative design was important as technical specifications allowed for incremental changes and were in line with RtD approach. The tool enables a previously difficult design situation in which physical distance and problems surrounding time planning (time zones, daily schedules) created obstacles to co-design. This research opens the door for more research into new tools that enable creative expression, new ways for intergenerational groups to work together and an opportunity to explore the experiences of the participants.

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Figure 1 Curious Child by curious lee (http://www.flickr.com/curiouslee) used under Creative Commons CC BY A.

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