

# DisCo: a co-design online tool for asynchronous distributed child and adult design partners

Walsh, G., Druin, A., Guha, M.L., Bonsignore, E., Foss, E., Yip, J.,  
Golub, E., Clegg, T., Brown, Q., Brewer, R.

Greg Walsh, Allison Druin, Mona Leigh Guha, Elizabeth Bonsignore, Elizabeth Foss, Jason C.  
Yip, Evan Golub, Tamara Clegg, Quincy Brown, Robin Brewer, Asmi Joshi, Richelle Brown

Human-Computer Interaction Lab  
University of Maryland  
2117 Hornbake Bldg, South Wing  
College Park, MD 20742  
Telephone number, incl. country code  
[gwalsh,adruin]@umd.edu

## 1. ABSTRACT

Face-to-face design with child and adult design partners is not always possible due to distant geographical locations or time differences. Yet we believe that the designs of children in areas not co-located with system builders, or who live in locations not easily accessed, are just as important and valid as children who are easily accessible especially when designing for a multi-national audience. This paper reports on the prototype design process of DisCo, a computer-based design tool that enables intergenerational co-designers to collaborate online and asynchronously while being geographically distributed. DisCo contains tools that enable the designers to iterate, annotate, and communicate from within the tool. This tool was used to facilitate distributed co-design. We learned that children were less forgiving of their inability to draw on the computer than on paper, and they formed small, intergenerational design teams at their own locations when the technology did not work as they expected.

### 1.1 Author Keywords

Design, Children, Participatory Design, Cooperative Design, Co-Design

### 1.2 ACM Classification Keywords

D2.2. Design Tools and Techniques: Evolutionary Prototyping

### 1.3 General Terms

Design

## 2. Introduction

*"A board game to teach kids to read would be cool..." explains Roberta. Enoch agrees by suggesting, "You should be able to integrate your ebook reader into the game." Agatha adds "I would do a board game that involves reading and for them to be able to move around...". Oliver suggests a new tack, "I think readers who want a challenge should take a new path" and Alice*

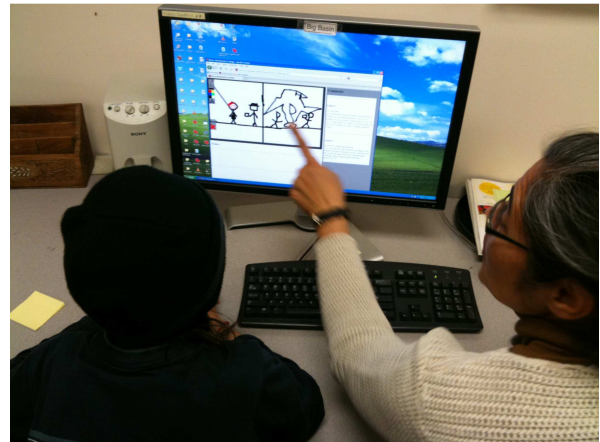


Figure 1 - Design partners work with the DisCo tool.

*June adds that players should take a quick reading test so the game knows how well players can read and adjust the game based on it. The design discussion finishes as Max adds, "The board game should be played on a phone and have READ spaces that need you to read from a story when you land on them."*

This design experience took place between children and adults online. Together they asynchronously designed a reading game using DisCo, an online tool for distributed co-design. Each child was in his or her own home in three different time zones of the United States because DisCo can support geographically distributed, asynchronous, intergenerational cooperative design.

This computer-based design tool can facilitate cooperative design, or co-design. We define co-design as a category of participatory design in which all partners in the design process can have an equal say [6]. Low-tech prototyping with paper [21], post-it notes [3] and art supplies [13], are techniques used to communicate design ideas between partners in the co-design process. Prototypes can range from a drawing representing a screen to a three-dimensional, low-fidelity prototype made of cardboard.

As communities become more global, there is a need to use co-design techniques with geographically dispersed audiences, or

distributed co-design, especially when designing for multi-national audiences. There are multiple considerations when working with a geographically dispersed co-design team including online prototyping, communication channels, and time zone considerations.

Currently, distributed co-design is achieved with non-interactive media like paper and sticky notes physically sent via courier, or non-iterative, computer-based methods like e-mail. Distributed co-design is also possible if members of the design team travel to each of the participant's location. However, distributed co-design is currently difficult because of the multiple individual idea streams that the distributed co-design teams must manage, such as text from an e-mail or graphics from an image file, or the cost of travel [6]. Besides the difficulty in organizing relevant media, distributed design teams need a way to see the iterations between versions and prevent versioning errors. These limitations place a burden on all but the original contributor and may reduce participation by remote teams.

New tools and techniques need to be developed in order to support the inclusion of children and adults, regardless of location, in the design of new children's technologies as part of a real team with real budget and time constraints. It is critical to support children in the design process because adults do not experience the world as children do and do not have the same insights into the world as a child [18]. When children and adults can be design partners, adults are able to bring their world-view to the design sessions in the same way that children bring theirs [7]. More importantly, the designs and ideas of children in areas not co-located with system builders, or who live in locations not easily accessed, can offer diverse points of view and design suggestions that are not normally heard.

This paper begins to investigate distributed co-design through the co-design of a computer-based tool with our intergenerational team and tries to answer the following question: What is required from a computer-based design tool to facilitate distributed co-design with children?

### 3. Previous Work

Cooperative Design is the inclusion of the end-user in the design of new technologies [17]. Originally developed as a way for workers afraid of displacement by machines [1] to have a say in the technologies that they would use in the workplace, the groups using participatory design methodologies have expanded over the years. Cooperative Design often includes techniques that help participants communicate their ideas and generate requirements for system designers.

#### 3.1 Prototyping

The use of paper as a medium in participatory design is popular through the use of low-fidelity or low-tech, paper prototypes [21]. Paper prototyping provides user feedback early in the design process. Paper prototypes can be as simple as storyboards, or more complex requiring multiple researchers to imitate a computer. Paper prototyping can be effective because end-users are more likely to focus on content instead of appearance [20].

Storyboards, originally used for film and television production design and later modified for interactive educational media [19] are simply low-tech pictures either hand-drawn or created with layout software that represents what happens on each screen. Paper-based storyboards are static and communicate steps or screens while being limited in their ability to represent interaction.

More elaborate types of paper prototypes require several people to execute with a participant. In the design of a robot for ophthalmology [12], a team was made up of three researchers and one participant. One researcher acted as the leader and ran the session. One researcher acted as the computer and manipulated paper elements based on the input of the end-user. Finally, one researcher observed and took notes.

One of the earliest participatory design tools that leveraged paper-prototyping with new media was PICTIVE [16]. PICTIVE combined low-tech prototyping materials with high-tech video recording. PICTIVE used a shared design surface and included a number of low-tech materials like labels, highlighters, colored pens, Post-it notes and pre-made icons. The video equipment recorded the design team working on the shared surface. The idea of "Plastic" is important to PICTIVE because items are made of plastic, plastic in the sense that designs are easily changed, and plastic as artificial because one can't confuse the prototype with a working system.

Similar to PICTIVE's shared physical space, the Cooperative Interactive Storyboarding Prototyping (CISP) [14] approach used a virtual space on the computer screen. The goal of CISP was to aid the researchers in designing a better VCR interface. The first iteration of the method asked users to perform a task with the lab's then-recently purchased VCR and had them describe what they were doing. The sessions were recorded but obstacles including occlusion of the camera and poor voice recording reduced the efficacy of the artifacts for research.

The second iteration of CISP was built with HyperCard. This iteration of the method used a palette of building blocks for people to develop user-interfaces on the screen. The users could design a system on the screen that really controlled the connected VCR, test their system with other users and capture real-use data that was unavailable with only a video recording.

The previously mentioned techniques were similar in their shared workspaces, however, collaboration between users occurred in real-time (PICTIVE) or, more loosely defined, using an iterative, design-test-redesign method (CISP) and only occurred in the fixed-location of the tools. Although each one is described as having taken place in a fixed setting, it is possible that either one could take place in various geographic locations as long as travel, time or cost was not an issue. Another important distinction about these techniques is that they were not designed with children in mind. These design techniques were created with adults as their primary user.

#### 3.2 Cooperative Inquiry

Cooperative Inquiry [7] is one method of participatory design in which design researchers work *with* children on the design of new technologies *for* children. The children work as full partners in the design of these technologies and are not merely seen as informants or testers.

The University of Maryland's Human-Computer Interaction Lab has an intergenerational design team based in cooperative inquiry. The team is comprised of eight to ten children ages 7-10 and six to eight adult researchers from a variety of backgrounds (HCI, Computer Science, Education). The intergenerational design team meets for a two-week design camp in the summer and then twice a week after school during the academic year. The participants agree to join Kidsteam for a full year and many join for multiple years [5, 7, 8].

The team uses a variety of techniques for their low-tech prototyping. They use art supplies, large pieces of paper, markers, and sticky notes to do design work. The group has begun investigating new co-design techniques for designing increasingly mobile and social technologies used by today's children as well as techniques that can engage a wider age-range of children [9, 13, 23]. These investigations led to the development of Layered Elaboration.

Layered elaboration [22] uses over-head transparencies applied over a piece of paper that has a design on it. This technique was chosen as the basis for our distributed co-design research because it supports asynchronous co-design, enables creative expression, and could easily facilitate communication between designers with the addition of computer-based tools.

Layered Elaboration is useful when conducting Cooperative Inquiry because several designers can contribute ideas in a non-destructive way. In a traditional low-tech prototyping session, when one designer adds an idea to another's design, that original design becomes permanently changed. For example, if one designer builds a model of an airplane with craft materials and another designer adds a piece to it, that original design has been changed and reverting back to its original form is often difficult or impossible. Likewise, when using paper to make designs, it is often impossible to go back to an original design after someone else has drawn on it with marker. If the first designer uses paper and then each subsequent designer stacks a transparency on the drawing, the ability to "roll back" the changes becomes very easy. Co-designers may be more likely to contribute ideas if they do not feel like they are destroying another's work. Madsen and Aiken have written that the key to prototyping is the concept of iteration as a "discovery process" and that each iteration brings the prototype closer to addressing the user's needs and enables the user to become a co-developer [14].

Cooperative inquiry is a useful method, but, its current manifestation, the intergenerational design team, is only practical with children and adults who are geographically near and whose schedules coincide as to be available at the same time. In its mission to develop technologies that better serve children, children and adults from other geographic areas need to be included in the design process.

### 3.3 Distributed Co-Design

One project that attempts to make geographically dispersed, cooperative design work is the PICTIOL project [10]. PICTIOL is based on and shares features with TelePICTIVE [15], an online version of the PICTIVE design technique. PICTIOL seeks to mimic PICTIVE with an online design space using predesigned shapes, "sticky notes", and some drawing tools. Like TelePICTIVE, PICTIOL allows users to design user interfaces in synchronous sessions. Both also break the users into distinct roles like manager, designer, developer and end-user.

Although TelePICTIVE and PICTIOL allow participants to design together, they require synchronous connectivity. Synchronous activities can become difficult when participants' local time zones are far apart. For example, if one participant is in London, while another participant is in Los Angeles, they are separated by over eight hours. That means that one participant's morning is another's evening and their window to collaborate is small.

Another example of geographically dispersed, cooperative design can be seen in the design and development of the International

Children's Digital Library (ICDL) [6]. For this international project, the design team had to modify their traditional co-design techniques like sticky noting, low-tech prototyping, and idea frequency analysis, or "Big Ideas" [13], to work with a geographically dispersed group.

For example, instead of sticky notes to denote likes, dislikes, and design ideas, a paper matrix was created for design partners to write those same thoughts and then mail it back to the design leads at the University of Maryland. Similarly, instead of low-tech prototyping, children from geographically dispersed areas drew pictures on paper and mailed them back. Once a year, a team member would travel to the different countries to interview the children about their designs to get some insight.

The ICDL team ran into a different, yet important, challenge in distributed co-design in comparison to PICTIOL and TelePICTIVE. The quality of interaction between co-designers usually encountered was reduced because of communication media. The time to mail something internationally, the cost to travel to a site, and the lack of iterations and elaboration by all parties in a timely manner may reduce the speed of development of the project. Thus, a technique that is usable by designers around the world when they are available, yet updates instantaneously, and manages the iterations between versions would be a powerful co-design tool.

This need for a geographically distributed, co-design team was again highlighted when with the students and facilitators of the Carnegie Hall Cultural Exchange program [23]. In this program, students from New York City, Mexico City, and New Delhi participated in activities in the classroom and in an online social network. Carnegie Hall worked with the student ambassadors, participating students chosen by their teachers, to help improve the semester-end concert experience because they felt as though students had not fully participated nor enjoyed it in the past. Each location had co-design sessions; however, there was no interaction between locations except the adult facilitators of Carnegie Hall that traveled. This co-design situation is similar to the one experienced by the ICDL team [7].

Synchronous, co-located co-design sessions would be impractical with the students due to travel cost and time. Synchronous, distributed sessions, such as video conferencing, would be impractical between New York and New Delhi because of time-zone differences. The only solution for a scenario like this would be an asynchronous, distributed co-design session.

### 3.4 Design Requirements

To address the needs of a geographical distributed co-design audience, the authors designed and implemented a prototype web-based software package to facilitate Layered Elaboration. To accomplish Layered Elaboration in an online setting, a distributed co-design tool needs to support: users who are geographically distributed, elaboration between designs, and creative expression.

The distributed co-design tool, DisCo, was designed to expand Layered Elaboration from a paper-based technique to an on-line environment that allows co-designers to work asynchronously and manages iterations of designs. Layered elaboration was chosen as the base technique because it is asynchronous in its execution since only one design group works on one design problem at a time. The discussion that occurs between iterations in layered elaboration enables the next design group to understand the current design and add to that design. If that is the case, then the

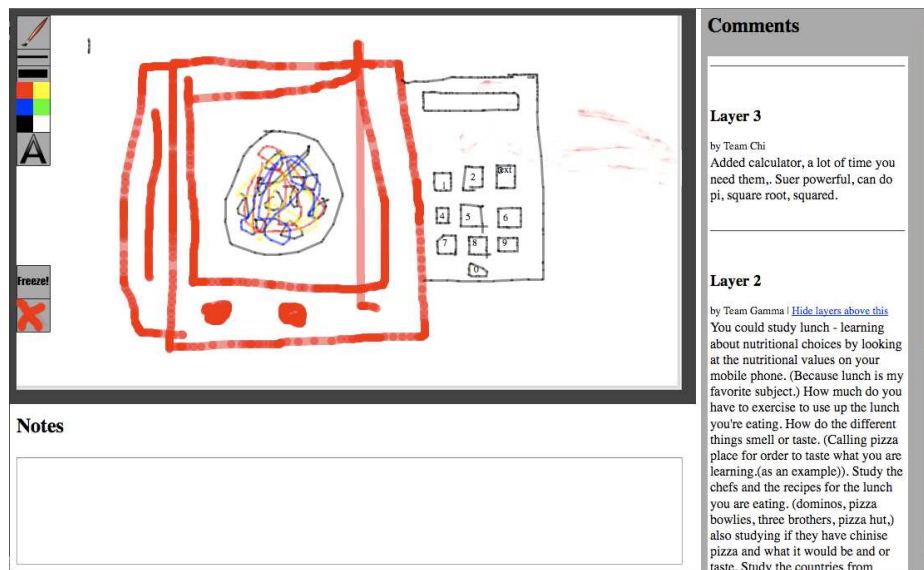


Figure 2 - First Version of the DisCo tool.

time between iterations would not matter if a description for the next designer was available to build upon.

DisCo is based on previous literature in co-design methodologies and techniques. Unlike, PICTIOL and TelePICTIVE, collaboration does not happen in real-time. However, DisCo is more than an online whiteboard because it supports asynchronous communication and manages iterations between users. DisCo breaks down power roles in accordance with cooperative inquiry and encourages creative expression without fear of permanently destroying something.

## 4. Method

The goal of this paper is to answer the question: What does a computer-based design tool require to facilitate distributed co-design with children? The authors used a Research through Design approach and utilize Cooperative Inquiry as the method to arrive at the design.

Research through Design is an emerging area of the Human-Computer Interaction field [25]. With Research through Design, researchers design and build prototypes informed by outside disciplines, such as anthropology, ethnography and computer science. Through iterating and critiquing, the problem is reframed. The outcomes of research through design include identifying a concrete problem and the ideal state as well as artifacts such as models, prototypes, process, and documentation.

Our approach in creating DisCo can be seen as design inquiry. In design inquiry, a “wicked problem” is identified and through iterative development of prototypes, a novel solution is identified that solves that specific problem in that context [24]. In the case of this research, the wicked problem is the inclusion of children and adults, regardless of location, in the design of new children’s technologies as part of a real team with real budget and time constraints.

In keeping with design inquiry, the first version of DisCo was designed to mimic the paper-based technique of Layered Elaboration while adding a small number of features available only on the computer and necessary for distributed teams. The

intergenerational design team utilized the tool in design sessions and ideas from the design partners, as well as observation of use, informed the next prototype. This repeated five times.

## 4.1 Participants

The research project took place over 18 months. There were 20 child participants and 12 adult participants during the project because it spanned three constitutions of the intergenerational design team: spring 2010, summer 2010-spring 2011, and summer 2011.

All of the children were between the ages of seven and eleven. The adult participants were researchers from the following fields: information studies, education, and computer science. One researcher was also the parent of one of the participants.

## 4.2 Materials and Technology

The first three prototypes were used in a computer lab setting while the final two prototypes were used outside of the lab. The lab setting was comprised of two rooms with eight or more computers in each room. The lab research utilized the Mozilla Firefox browser with the Adobe Flash plugin running on the Microsoft Windows operating system.

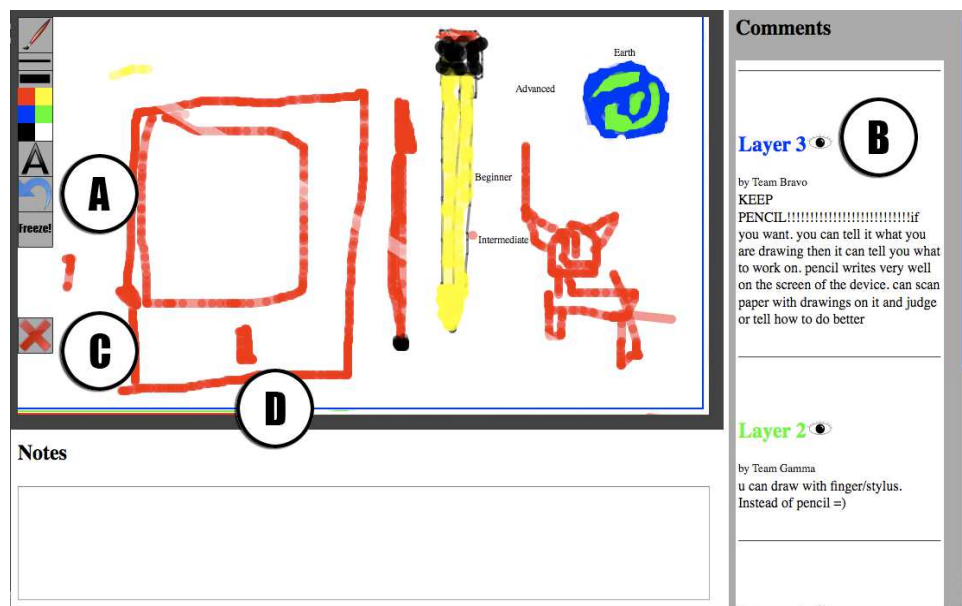
The data collection included observations, group discussions, and co-design sessions. The research also involved open-ended interviews with the children and parents in the summer of 2011. The interviews were all conducted over the phone.

All of the prototypes were built using Adobe Flex, Pre-hypertext Processor (PHP), JavaScript, and a MySQL database. When the prototypes were deployed to a geographically distributed audience, Drupal was used to authenticate and communicate.

## 4.3 Procedure

### 4.3.1 First Prototype

The first prototype was based on the features of Layered Elaboration, and included the drawing area, the ability to add layers, and a way to communicate the designs to the next designer. The screen is divided into three parts: a canvas for drawing to



**Figure 3 - Second version of DisCo tool. A- Undo Button, B-Visibility & Solo Toggle, C-Exit Button, D-Color Coded Outline**

support creative expression, a box for annotating the design in order to pass ideas onto later design partners, and a comments pane that displays the designers' annotations for their respective layer to facilitate elaboration (See Figure 2). The canvas contained a paint brush for designers to draw, a simple color palette, a tool for adding text, a discard button, and a save button called "freeze" to mimic the verbal alert used in the paper-based version of the method. Designers were able to hide all the layers above a selected layer, similar to removing a stack of transparencies from a paper-based design.

In order to assist another research project, an intergenerational co-design team used the first version of the prototype in Spring 2010 to design a mobile user interface for: doing homework, hanging out with friends, doing classwork, going on vacation, and watching television. The group initially sat in a circle to discuss what the group was going to be doing that session. The design session facilitators explained that the design teams would be designing mobile user interfaces, but that they would be using the computer instead of paper and transparencies. The first question asked was, "Won't that be harder?"

Each child-member was paired with an adult and was assigned a computer and team name (See Figure 1). Four of the teams were in Lab A, and the remaining two were in Lab B across the hall. Each team was assigned a team identifier and one of the topics. They were then given ten minutes to create a design about the assigned topic. One researcher walked around taking notes, answering questions about the tool, and troubleshooting when necessary. Towards the end of the ten minutes, the designers were reminded to annotate their design in the Notes area and press "Freeze" when done.

After the ten minutes were over and all the designers were asked to stop designing, a researcher walked around and gave each group the next topic to design in the next ten more minutes. One boy didn't know that when he went on to the second topic that there would be a design there for him to elaborate and thought

that was "really cool". Although they had ten minutes, most seemed done or had submitted within 7 minutes..

For their final round of design, each group was given their next topic and was asked to use sticky notes to provide design ideas on the DisCo tools. Most of the teams were done elaborating the designs in about five minutes. In this round, they were both elaborating on the user designs and providing ideas on how to make the tool better through the use of Cooperative Inquiry techniques.

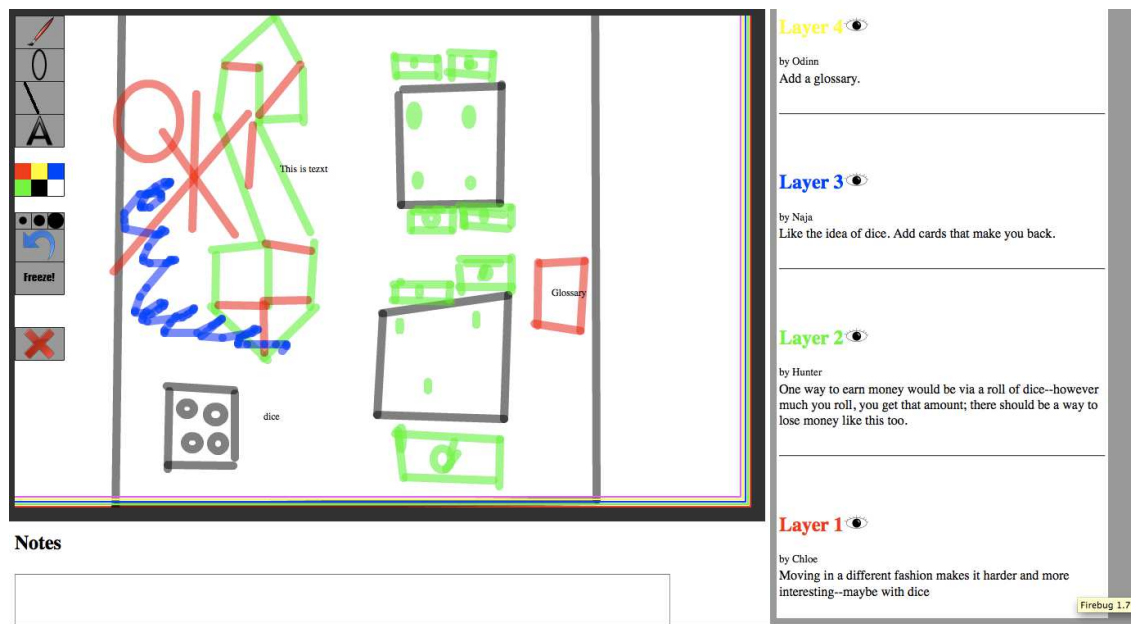
There was an average of three design ideas that could iterate on the tool per group. During this time, a researcher collected the ideas to be placed on the in-lab whiteboard. After the three design sessions, the group reconvened in the main space and discussed the ideas for the tool that were collected on the white board. By engaging in the tool's design process, the team members truly became co-designers of the tool.

This discussion, or the "Big Ideas" session is integral to the Cooperative Inquiry method. It is during this time that the ideas for the day are captured, organized, discussed, and synthesized by all the members of the intergenerational design team. The output of this period is what the next iteration of the prototype is based upon. Because these are design ideas, it is up to the developer to decide what can and cannot be implemented.

Based on the design session, more tools were added to the canvas and the comments tracker was rewritten (See Figure 3). Although the group had many suggestions in the initial design session, changes were made based on prioritizing the needs of a distributed co-design environment.

#### 4.3.2 Second Prototype

In order to incorporate the design ideas generated and the shortcomings observed in the first iteration, modifications were made to the prototype. An undo function was added to address the most popular design suggestion (See Figure 3, Area A). This feature is important because it supports creative expression by helping to prevent the user from being frustrated from having to



**Figure 4 - Third iteration of DisCo**

delete and restart the design when a mistake is made. Similarly, we modified the Clear All button to give feedback with a roll-over, changed its icon, and moved it away from the save button (See Figure 3, Area C). Again, this supports creative expression through a reduction in frustration.

The layer visualization functions were modified to include a hide and show function activated by an eye icon (See Figure 3, Area B). This is similar to Adobe Photoshop's [26] and the GNU Image Manipulation Program's [27] hide/show convention. This change supports elaboration by helping the user associate the design notes left by previous designers with the corresponding graphic layer.

Additionally, when a designer rolls over a layer's "eye", that layer stays at full visibility while the other layers faded back to 25% transparency. We call this "soloing" a layer. The faded layers' eye icons also fade back as well.

Each layer was given a color. The layer's name was written in that color in the comments section. The layer's outline on the drawing canvas was drawn in that color (See Figure 3, Area D). This, too, addresses the suggestion for better layer visualization. Like the previously mentioned eye icons, this change enhances the software because it supports the elaboration process by more explicitly identifying which layers are being described by the design notes.

The second prototype session was one week after the first session. In order to explore what the design partners could do with the tool, we asked each of the children to come up with a problem that could be solved with technology and use DisCo to design the solution. They wanted to create a diverse array of problem-solving devices: a device that helps you learn to draw, a device that automatically does your hair, a device that helps you not be hungry in class, a device that helps prevent bullying, a device that physically helps you read a book, and a device that helps you play video games.

Much like the previous session's discussion, all of the design partners (adults and children) met to discuss the design ideas. The

collected ideas were grouped into the following categories: layers, undo, textbox problems, interface, drawing tools, and colors.

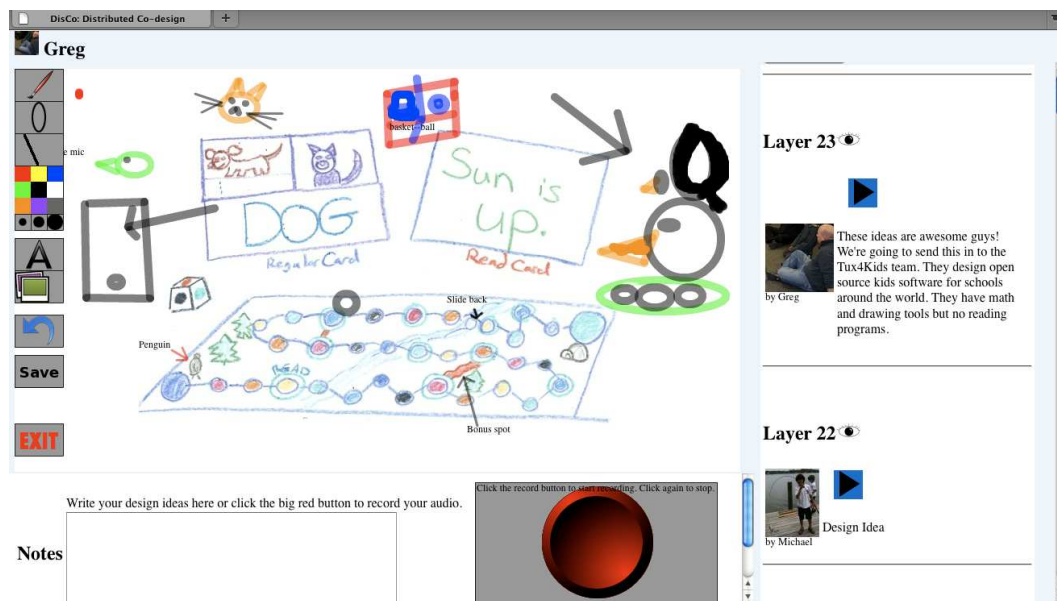
The ideas that had to do with layers and undo were actually positive comments that reinforced what worked well. One designer liked the color-coding of the layers. Three of the five comments said that they liked the eye feature. Likewise, one designer liked the new undo feature enough to comment on it. This demonstrates that the changes regarding layers and undo helped support geographically distributed users, elaboration, and creative expression in a design environment.

The remaining design ideas largely dealt with those things that limited creative expression. Design ideas about the location of text boxes, the way the color-coded layers appeared, and new drawing tools were mentioned.

### 4.3.3 Third Prototype

Based on the design ideas generated about the previous prototypes, changes in appearance and functionality were made to DisCo. The design partners had trouble drawing straight lines and felt as though more complex drawing tools were necessary, so, a tool was added to draw lines of varying thickness and color. A circle tool was also added. In order to address the designers' desire for more autonomy over moving from one design challenge to another, we created a rudimentary version control system that locked the design while being edited by another user. The system would block other users from being able to access the design if someone else had already chosen to elaborate on that design. The design would remain locked until the current designer had saved and exited via the "Freeze" button.

The third version of the prototype was used in the Summer of 2010 for use in the design process of a game that teaches financial literacy to children. The game was originally designed as a board game and the creators wanted to move it to a computer-based environment. The Kidsteam group was broken up into smaller design teams in a similar way to previous design sessions. The four design challenges were: design a computer game based on the board game, redesign the board game, create a mobile game,



**Figure 5 - Fifth version of DisCo used to create a game to teach young children how to read**

and design a character builder for a financial literacy role playing game.

Because it was summer and we were working with a new group of intergenerational design team members, the design team was unfamiliar with DisCo. Some of the design paradigms based on Layered Elaboration or used by the previous group, such as “Freeze” for save and the arrow symbol for undo, needed to be explained to the new members. Most of the other tools were intuitive and the designers were able to successfully design and elaborate on other users’ designs.

This design group contributed two ideas for improvements to future versions: the ability to record audio instead of type and the ability to import images and photos into the canvas area. These ideas had been suggested in passing by the previous Kidsteam, but had not been added due to available resources and prioritization of features. But as the prototype had matured, these features became more noticeably absent and were affecting creative expression.

#### 4.3.4 Fourth and Fifth Prototypes

The fourth and fifth prototypes were used in the Summer of 2011 as part of an online environment to foster geographically distributed co-design. The participants were not in a lab environment, but instead, at home, at a family member’s house, or on vacation when accessing DisCo.

Design partners would log in to a system and navigate to the design tool. Here they were presented with a list of design challenges in which they could participate. Extending the user’s ability to have exclusive control of a particular design, this prototype version would notify designers that another designer was actively working on it with a “busy” display in a similar way to earlier prototypes.

Because the group was unable meet face-to-face, the fourth version included an avatar in the comments section that the designers could upload through a profile tool. New to the drawing tools was the ability to upload photos to the canvas area. Removed from this prototype was the visual indication of layers.

This was necessary because as the number of design partners grew, the number of visual indicators became distracting. Also removed was the “Freeze” button and it was replaced with “Save”. Finally, an exit button was added in order to allow designers to leave without saving. This version was used through most of the summer as part of the online co-design environment and was used in the design of several different technologies.

The fifth version of the prototype was essentially the same with the addition of voice recording functionality and new colors available in the drawing area. Designers could type notes about their design and/or click the large, red button to record their ideas verbally. This was in response to participants having trouble typing. Both text and audio controls were presented in the annotation section of the tool.

Using the fifth version of DisCo, the intergenerational design team was able to design a computer game whose goal is to teach young children how to read (See Figure 5). The game was designed to mimic a board game and involves a penguin that must get back to her igloo by choosing the correct picture that corresponds to the word displayed on the screen. The team envisioned that the game would be multiplayer so young children and parents, siblings, or caregivers could play along.

## 5. Discussion

Through iterative co-design, a computer-based design tool has been developed that facilitates distributed co-design with children based upon Layered Elaboration. Although the tool was useful for co-design from the beginning, it was not ideal nor could it stand on its own. The first three prototypes were important in the design process because they illuminated the changes that needed to be made for the tool to move from paper-prototyping-on-computer to a tool that kept the goals of Layered Elaboration while leveraging the unique affordances of a computer (networked connectivity enabling geographically distributed participants). It wasn’t until the fourth prototype that it was evident that DisCo emerged from trying to be analogous to the paper based tool and became a unique computer-based co-design tool that upheld the

ideals of Layered Elaboration (creative expression and elaboration between users) while enabling geographically distributed co-design.

The problem continued to be clarified throughout the design process. The first prototype was the authors' attempt to solve the initial problem of distributed co-design. However, it became apparent that tools analogous to paper-based tools were not enough. In a paper-based Layered Elaboration design session, participants are only given a few colors to work with, yet, participants wanted more colors on the computer-version. Similarly, design partners do not use straight edges in their paper-based designs but were extremely frustrated at the inability to draw straight lines on the computer-based version. *Children had higher expectations of their own ability to draw with a computer-based design tool than of paper-based techniques*, an expectation that we needed to accommodate with additional design features, such as more detailed drawing tools.

More importantly, our users did not want to draw with the computer. Several times through the design sessions and 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. In fact, the first week of using the fourth prototype in the field saw participants trying to use Apple iOS devices. There was a perception that complex computer interactions (recording voice in a browser, drawing on screen) were easier on one of these devices. In a way, *our child participants have moved beyond the traditional computer-based web browser as an application deployment tool and onto touch screen devices*. The next version of DisCo is being developed for use on Apple's iPad and an investigation into co-designing with a touch screen compared to using a computer mouse will take place.

Another 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. In fact, 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. Some parents and children took a decidedly low-tech approach and had a parent type for the child. In a sense, *the participants created their own intergenerational design teams at their end*. This breakdown of roles between children and adults is very similar to how a Cooperative Inquiry session takes place in our lab environment. The next version of DisCo will support the addition of ad hoc design partners so that existing partners will be able to add parents or siblings to the design process.

Based on what Chipman et al described as "scribble wars" [4] with clearly defined areas of conflict, we had expected some designs to have used the white paintbrush to clear another user's idea. Instead, we observed the children making an effort to elaborate on the design challenge. The good-faith effort by the participants may be due to their experience with Kidsteam, although not every participant had been with the group before beginning to design with DisCo. A good-faith effort supports elaboration between designers, which is critical to the distributed co-design process. This has led us to believe that *participant designers who know each other seem to make a good-faith effort*

*to add to a design*. DisCo will be released to a larger group of child designers and this phenomenon will be investigated further.

*Distributed co-design on the computer requires an extra level of facilitation that is often taken for granted in co-located sessions*. Online, distributed co-design cannot take place with only a tool like DisCo. In the first three prototypes, all facilitation was handled by a researcher telling groups when and what they should work on next. Clearly explaining design challenges and providing scaffolding on using the system became important when DisCo was used in the field. Most of the development effort between the third and fourth prototypes went into the facilitation framework (authentication, communication, avatars). This larger technology framework is what enabled DisCo to successfully enable true distributed co-design in a real-world environment and is promising as a framework to support other computer-based co-design techniques.

Another dimension to this research is that we took a Research through Design approach in order to build a tool that can be used to conduct Research through Design. More specifically, this process could be called *Research through Co-Design* because participants were part of a culture that values partnership between children and adults and has well-established communication techniques. In the early prototypes, there was meta-design occurring because the design partners were not only designing some new technology with the tool, but were also co-designing the tool they were using to design those new technologies. This meta-design occurred explicitly during all of the prototypes.

This is different than typical Research through Design projects in which a prototype is made, participants use it, researchers observe and evaluate it, and a new prototype is made [2, 11] so the cycle can continue. Instead in our process, researchers built a prototype, used it with our design partners, the design partners critiqued the experience and generated new ideas so that a new prototype could be built. The difference between Research through Design and Research through Co-design being that the design partners do more than just inform the direction for the future, they are active participants in the next design. This is inline with the philosophies of cooperative inquiry [5].

## 6. Conclusion and Future Work

This new computer-based system enables co-designers to work asynchronously while being geographically distributed. However, this is just one solution to addressing this challenge of inclusion. Regardless of location, children can be involved in the design of new children's technologies as part of a real team with real budget and time constraints, and as revealed through the difficulties with audio, real technical constraints as well.

Moving forward, more investigation needs to be done to understand the transfer of design methods used in-person to an online environment. DisCo is analogous to the design technique, Layered Elaboration. Other online tools that support the inclusion of geographically distributed children and adults can be designed from existing in-person techniques; however, what is the larger framework that they should be used in? If an intergenerational design team is the in-person, co-located manifestation of Cooperative Inquiry where Layered Elaboration is used, what is the online manifestation of Cooperative Inquiry in which DisCo is used?

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