

Designing Technology with Students with Learning Differences:
Implementing Modified Cooperative Inquiry

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IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Abstract

Cooperative Inquiry provides a framework for involving children in the design process of technologies intended for use by children. Traditionally, the Cooperative Inquiry approach has been applied in laboratory settings with typically developing children. To extend Cooperative Inquiry to better suit diverse populations, the authors build on previous work conducted in a classroom with students with learning differences. Four implications for modifying Cooperative Inquiry when working with children with learning differences, drawn from the authors' previous research, were implemented in the current study. The recommendations of (1) informal social time, (2) high adult-to-child ratios, (3) verbal as well as written instructions, and (4) planning for high levels of engagement were used to engage ten boys ages eleven and twelve with diagnoses of learning disabilities, Attention Deficit Hyperactivity Disorder, autism spectrum disorders, and anxiety disorders. These students and researchers, working as a team, developed an adventure-based computer game while following the modified form of Cooperative Inquiry. The first three recommendations were upheld during the current study, with the fourth not observed as strongly as during the initial work.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Introduction

The philosophy of Participatory Design (PD) maintains that the end users of a technology should be represented during the design process of that technology (Schuler & Namioka, 1993). When developers of software or other technologies work with the intended users of their products during the design process, the eventual products should better suit the specific needs of the user group. While PD is traditionally practiced with adults (e.g. Kensing & Blomberg, 1998), researchers have extended the philosophy of inclusion inherent in PD to children (e.g. Druin, 1999). Methods within the PD philosophy for accomplishing design work with children are broad, with ideal method choice largely dependent on the context of the design work (Scaife & Rogers, 1999).

Existing research establishes that children with disabilities should have equal opportunities as children with typical development to impact the design of technology (Alper, Hourcade, & Gilutz, 2012). Further, children with disabilities experience benefits when they engage in PD activities. For example, technologies developed using PD methods with children with disabilities have been shown to improve communication skills (Bonsignore, Quinn, Druin, & Bederson, 2013; DeLeo & Leroy, 2008), provide entertainment for children (Alper et al., 2012), expand learning experiences, and allow for improved social interactions (Madsen et al., 2009). While these studies have had success working with children with learning differences, there remains a need to develop a deeper sense of the methods and practices needed for engaging such groups in participatory design.

The current research builds on a previous study applying PD methods with a population of children with learning differences (Foss et al., 2013). The initial study included a classroom of 10 boys ages 11 and 12 with learning disabilities, autism spectrum disorders (ASD), Attention

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Deficit Hyperactivity Disorder (ADHD), anxiety disorders, or comorbid combinations of these conditions. Using Cooperative Inquiry, a child-specific method of PD, the previous classroom and researchers worked together as design partners to develop a prototype computer game. At the conclusion of the study, researchers made recommendations for modifying their PD approach when working with comparable populations by assessing the challenges and successes of the study. However, the recommendations for altering the method were derived after the design work of the initial study was completed and had not been enacted with participants. Thus, the current research reports on a follow-up study to confirm the efficacy of the modifications by employing them in a second and similar classroom.

Cooperative Inquiry

Cooperative Inquiry is one method of conducting PD work with children (Druin, 2002; Guha, Druin, & Fails, 2013). One of the most important aspects of Cooperative Inquiry is *idea elaboration*, where an adult or child first shares an idea with the group, and then others expand on the thought until at the end of the process it is “our idea” rather than “my idea” or “his idea” (Guha et al., 2013). Through idea elaboration, Cooperative Inquiry enables children and adults to become equal stakeholders, or *design partners*, in the development of technology. Working together, design partners engage in a range of activities, or *techniques*, to further the creation or improvement of a technology (Walsh, Foss, Yip, & Druin, 2013). Low-fidelity prototyping, cluster analysis, journaling, drawing larger-than-life models, and rapidly iterating on sketched ideas are all techniques used to elicit system requirements. These techniques are appropriate to use at varying points in the design cycle, and child design partners are involved whether a system is novel or near release.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Cooperative Inquiry has been successful in drawing children into the process of creating or improving technologies meant to be used by children. It can also improve the social experiences of children (Guha, 2010) and often results in highly usable and engaging systems (e.g. Bonsignore et al., 2013). Children who are design partners develop friendships, gain skills in communication, collaboration, and confidence, report enjoying design work, and learn about the topics of the systems with which they engage (Guha, 2010; Yip et al., 2013). They are also empowered to advocate for their own technology needs and wants, regardless of impracticality. In the Cooperative Inquiry method, adult design partners thoughtfully consider children's ideas and distill core contributions (Guha et al., 2013). However, Cooperative Inquiry has mainly been applied in the past in laboratory settings and with groups of typically developing children. The current study expands Cooperative Inquiry to children with learning differences. Applying the Cooperative Inquiry method to a broader population not only further democratizes the technology design process, but also creates the potential for children with learning differences to experience the benefits of design partnering.

Lessons from the Literature

Prior research has established inroads into how to collaboratively design technology with children with disabilities. The following literature summary encompasses a broad spectrum of participant groups and PD approaches. While some researchers adhere to known methods, others develop new methods to engage children with disabilities. On the whole, this body of research represents positive steps towards including all children in the design process of technology.

The literature regarding designing technology with populations with disabilities recommends consulting a team of adults including parents, teachers, and caregivers surrounding

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

the children to participate in the design work (Alper, et al., 2012; DuPaul, Weyandt, & Janusis, 2011; Hornof, 2008; Millen, Cobb, & Patel, 2011). By *involving adult stakeholders*, researchers may gain additional insight into the design work (Millen et al., 2011), as well as understand differences between the population of interest and other groups (Alper et al., 2012). Involving adult stakeholders can also increase access to children with disabilities and ease the integration of technology into their lives (Alper et al., 2012). Other researchers heavily involve adult stakeholders in PD and consider how to support not only children with disabilities, but also their caregivers (Hayes et al., 2010). Although adult stakeholder participation can be important, Larsen and Hedvall (2012) note that the contributions of these proxies are of secondary concern when attempting to directly engage children with disabilities.

Allowing for *flexibility in methods* is also central when working with populations with differing needs. Researchers discuss that it is sometimes appropriate to include children with disabilities only at key points during the design cycle (Brederode, Markopoulos, Gilen, Vermeeren, & DeRidder, 2005). Children who contribute to design work at key points in the process are known as *informants*, as compared to design partners, who contribute throughout the process (Druin, 2002). Guha, Druin, and Fails (2008) discuss how to involve children with disabilities in design work. In Guha et al.'s model, researchers can support children with disabilities at varying levels of intensity to balance possible limitations or abilities. The authors advocate inventive tactics when finding ways to provide support. When working with children with autism, Millen et al. (2011) additionally endorsed a flexible approach. The authors discuss that while researchers may have prepared in detail for a design session, deviating or abandoning plans may be necessary.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Gaining *familiarity with the population* is recommended. Spending time with children with disabilities and getting to know individuals and the population can alleviate potential feelings of awkwardness for the researcher (Hornof, 2009). Researchers can also gain understanding of the differences among individuals and children with and without disabilities not only by engaging with the population, but also by reviews of other researchers' work and collaborations with experts (Alper et al., 2012). Researchers have established that being *aware of individuality* is an important factor when designing with children with disabilities (Alper et al., 2012). One approach to designing with children with disabilities is to take into account the individual's personal interests, which can be used for scaffolding activities within a design session (Benton, Johnson, Brosnan, Ashwin, & Grawemeyer, 2011).

Prior research has also found that there is a need to *increase the number of adults* present when conducting PD work with children with cerebral palsy (Hornof, 2008, 2009) or who have the autism spectrum disorders (Benton et al., 2011). Caregivers familiar with individual children can help researchers to better understand how to communicate (Hornof, 2009). For children with ASD, one-to-one support can combat anxiety about participating in PD activities (Benton et al., 2011).

The literature provides guidelines for good practices when engaging children with disabilities in Participatory Design. The research presented in this paper involves extending a modified form of Cooperative Inquiry to a population of children with learning differences. Four modifications to Cooperative Inquiry were drawn from prior work with a classroom of middle-school aged boys with learning differences. The goal of this research is to determine whether the recommended modifications to the Cooperative Inquiry method are useful in facilitating the design process with children with learning differences.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Research Methods

In this study, researchers participated with a middle school classroom of 10 boys with learning differences to develop a computer-based adventure game. The researchers implemented a modified form of Cooperative Inquiry to determine whether changes to the method would be effective to the design process and beneficial to the experiences of the child design partners. There were six design sessions to develop the game and a summary session to review the design process. At the conclusion of the study the class travelled to the researchers' university to share their game with a larger audience.

Four Recommendations

As stated, this research builds on a previous study that used unmodified Cooperative Inquiry in a similar classroom of 10 boys with learning differences. The previous study resulted in four recommendations for modifying Cooperative Inquiry when conducting design work with children with learning differences in the classroom setting (Foss et al., 2013). The recommendations are described below, juxtaposed with practices used with children with typical development in the lab, and the differences in how the recommendations were applied between the previous study and the current study are summarized in Table 1.

The first recommendation was to allow for *informal social time (RI)* between the adult and child partners. In the lab setting, informal social time occurs over pretzels, cheese snacks, and mugs of water as adult and child design partners eat snacks together at the beginning of each design session. However, the classroom context of the previous study imposed a more compressed timeframe for design work. The researchers' solution was to eliminate snack time entirely. However, in doing so, the researchers inadvertently also eliminated informal social

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

time. As a result, the children in the previous study were inquisitive about the researchers, but the researchers had little opportunity to personally engage with them. The analysis suggested that making time for unstructured conversation would help the team develop a solid relationship, familiarize researchers with individual children, and alleviate the curiosity of the child partners about the adults.

Second, the analysis resulted in a recommendation to maintain a *high adult-to-child ratio (R2)* during design sessions with children with learning differences. University students and researchers heavily attend Cooperative Inquiry sessions in the laboratory setting. Although a 1:1 ratio of children to adults is not unheard of, more often five to six adults will attend a session with eight children. During the previous study, three researchers attended sessions with 10 child partners. Fewer adults meant that often the adult partners were divided between acting as session leaders and fully partnering with children. Having more adults in co-design sessions might therefore allow one adult to transition from designing in small groups into a leadership role as needed. Additionally, the adults will be more consistent design partners when they are able to remain present to contribute ideas to their small group throughout the session.

Once the Cooperative Inquiry session begins in a typical lab-based design session, the adults often relay the instructions verbally. Children are able to ask for directions to be repeated at times of confusion. With children with learning differences, researchers found that simply stating instructions verbally lead to hesitation to participate, as attention to and auditory processing of verbal instructions can be challenging. Thus, as the third recommendation, the authors found that *verbally stating as well as writing instructions (R3)* consistently throughout the entire session gave children with learning differences a reminder as to the design prompt and the opportunity to process instructions in multiple ways.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Lastly, a typical design cycle in the lab setting can occupy an entire school year, with child partners only periodically engaging with a particular project. In the time between seeing iterations of a design, the child partners often forget their contributions. By contrast, the children with learning differences were able to see rapid implementation of their design ideas in the game prototypes, raising their engagement and ownership. Additionally, the prototypes demonstrated to the children that researchers listened to and implemented their ideas. In this way, the children quickly filled the role of equal stakeholder in the game design, becoming stronger design partners. Therefore, the fourth recommendation, *preparation for a high level of engagement (R4)*, can empower children to act as full partners in the design process. For example, highly engaged children might want to lead discussions or aid in synthesizing the team's ideas. Researchers should be prepared to alter session plans to respond if children are active and involved in ways other than initially expected.

Current Study Population

For this study, the independent school participating in this research is attended exclusively by children with learning disabilities. Many of the children attending the school have comorbid conditions, with one or more disabilities presenting in an individual child. These disabilities can include speech and language difficulties as well as the already-discussed ADHD, ASD, and anxiety. The classroom participating in this study was comprised of 10 boys ages 11 and 12. Nine of the children in this classroom had learning disabilities, with ADHD present in seven children, ASD present in two children, and anxiety disorders present in five children. Only one child diagnosed with learning disabilities had no comorbid conditions. At the beginning of the study, five of the children were age 11 and five were age 12. The participating classroom

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

was, by administrator report, overall slightly lower-functioning than the classroom from the previous semester's study.

The three researchers central to this study were all experienced in implementing the Cooperative Inquiry method within a laboratory setting. Their backgrounds varied, with experience in special education, psychology, and computer science. Additional researchers were present during each classroom design session to increase the ratio of adults to children on the design team, although these researchers were not always consistent. The rotating adult researchers participating in the design work brought in skills in learning science and human-computer interaction and were all familiar with Cooperative Inquiry methods.

Programming Considerations

The six design sessions resulted in a prototype computer-based game. The adult programmer built the game for easy distribution and installation on the multiple computers used during this study. The programmer also designed each game level so that she could make improvements and additions to individual game levels quickly to implement design requirements from the participants as the game design evolved. The programmer scanned images from student artwork and loaded them into the game, and these images could be improved or changed easily. The flexible game programming approach fit well with the iterative nature of Cooperative Inquiry, as the design team could make significant changes to the game during one session and the changes were readily executed for the next session.

Implementation of the Four Recommendations

The research team approached each design session with the four recommendations from the initial study in mind, attempting to use Cooperative Inquiry in a minimally modified way to

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

achieve a successful design experience through building design partner relationships with child participants. To implement the recommendation for *informal time (R1)*, the researchers arrived 10 to 15 minutes before each session and entered the classroom while the students were switching classes and putting away their textbooks and notebooks. For this brief time, each researcher held informal conversations with unoccupied students, sharing personal information when appropriate, such as hobbies or roles at the university, and asking similar questions of the students.

Secondly, as part of the Cooperative Inquiry method, there is a “question of the day,” which is typically related to the upcoming design session and which all design team members answer. For example, when designing an application to collect science data related to cooking, the question of the day might be, “What questions do you have when you are cooking?” In this way, the group’s attention is shifted to the topic of the upcoming design session. For the classroom setting, due to the limited time allotted for the design sessions (only an hour in the classroom; the lab setting allows an hour and a half), researchers decided to use the question of the day to get to know the children on a more informal level. Instead of task-focused questions, researchers posed questions such as “What did you do over your spring break?” By changing this aspect of the design session, the researchers hoped to adhere to the first recommendation of increased informal time.

To address the second recommendation of a *high adult-to-child ratio (R2)*, additional research team members were recruited to attend sessions at the school. For the classroom of 10 children, at least four researchers were present at each session, freeing one adult to work with each of three small groups of children. Due to scheduling conflicts and the lengthy time investment to travel to the participating school, the fourth researcher was not always consistent.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

The two classroom teachers additionally chose to be involved with the design sessions. While the teachers did not directly participate in design activities, they closely observed the design work and when necessary, redirected the students, further increasing the number of highly involved adults.

The researchers used the whiteboard in the classroom to meet the third recommendation of *writing as well as stating instructions (R3)*. While one researcher introduced the question of the day, a second researcher wrote the question on the board. As each child's turn to answer the question came, a researcher would ask, "What about you, what did you do on your spring break?" This type of inquiry reiterated the question of the day. The researchers then introduced the design prompt, and similarly wrote the prompt on the whiteboard, erasing the question of the day.

At the end of each session, the small groups rejoined to share their ideas during what is known in the lab as "Big Ideas," or a synthesis of ideas generated during the session. During idea synthesis with children with learning differences, one researcher recorded each small group's ideas on the whiteboard as the group presented. After all the groups shared their individual designs, the researcher drew connections between similar ideas or highlighted unique ideas while verbally describing higher-order themes. For example, a group with the idea of airplanes and a second group with the idea of birds would lead the researcher to describe the theme of flying. As these connections were verbal as well as drawn on the whiteboard, the children had multiple ways of processing the outcomes of their work. The idea synthesis process for children with learning differences mirrored the process used in the lab setting.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Finally, to address the fourth recommendation of *anticipating a high level of engagement (R4)*, researchers predicted that there would be a sense of agency among the participating children. Specifically, the researchers thought each child would have the desire to author their own design sessions to the greatest extent possible, extending from the rapid iteration of their design and the ability to see their contributions realized. Therefore, the researchers planned each session to allow for quickly altering approaches if children indicated a need for a different kind or level of involvement. For example, the researchers planned on taking responsibility for leading the question of the day each session. However, if the children wanted to ask different questions or lead the discussion, the researchers were prepared to follow completely different lines of inquiry or to cede leadership. Also, the researchers attempted to provide as many outlets for design ideas and feedback as possible, and brought materials so children could write, draw, or video record themselves at any point, despite the planned session activity.

Data Collection

The research team collected varied data to allow for a detailed case study description of each session, as well as a thick description of how the modifications to Cooperative Inquiry affected each session (Creswell, 1998). The data included photos and videos to document the design activities and behaviors of the children on the design team. Additionally, the researchers took participant-observation notes when able to do so without disrupting design work or when not directly engaged in design activities. Each design session resulted in design artifacts that allowed the researchers to understand the process in more detail. Immediately following the design sessions, the adult researchers met and conducted a peer debriefing during which they documented session observations and events through debriefing notes. At the end of the study,

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

children completed a questionnaire on which sessions they liked the most and least, whether the game design incorporated their ideas, if the design team worked together well, and what aspects they would change about the Cooperative Inquiry process.

Analysis

Initially, one researcher analyzed the collected data of photos, videos, artifacts, participant-observation notes, debriefing notes and questionnaire responses. This researcher used a case study approach to analyzing the data, seeking themes within the data that pertained to the application of the four major recommendations to the design sessions (Creswell, 1998). For example, the researcher read through debriefing notes, noting instances of agreement or disagreement with each of the four major recommendations. If, for instance, a debriefing note included information about the children sharing personal interests during planned informal time, this researcher recorded that the note aligned with the first recommendation. The researcher repeated this process for all of the types of data and for each of the four recommendations. During coding, the researcher remained open to additional themes that might emerge as new findings from the data, whether pertaining to the recommendations or not. Following the coding, a second researcher verified the findings through peer review (Creswell, 1998).

Design Session Results

For each of the six design sessions, the researchers selected a *design technique*, or activity used to elicit design ideas, (Walsh et al., 2013) that would best promote the iterative development of the game toward a natural conclusion. The authors applied all of the recommendations from the previous study whenever possible. What follows is a description of

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

each design session including the goal for the session, how the researchers implemented the recommendations, and the outcomes from the idea synthesis.

Session One: Choose a Design Direction

In in-lab design projects, the platform and domain (e.g. game, homework app) are often predetermined. To enable the children in the current study to be fully involved in the entire design process, per the recommendation to anticipate a high level of engagement (*R4*), the first session was devoted to choosing a technology platform and domain. The researchers brought iPads™, iPhones™, and laptops into the classroom. Small groups of children rotated through these platforms to gain experience on each device and form opinions as to the design direction for the project. Free play on the devices was encouraged to explore applications and programs in order to allow the children to see the broad number of possibilities for what they could design. On a researcher's personal computer, one child drew a detailed picture using Microsoft Paint™, which he saved with the title, "The eraser from Reader Valley." Other children played iPhone™ games or opened iPad™ storytelling applications. The researchers and children verbally brainstormed about what programs or applications would be useful or fun for them personally while exploring the devices. The adults wrote and shared the ideas arising from brainstorming discussions on large sheets of paper, per the recommendation of written and verbal information (*R3*). At the end of the session, the class voted on the platform for which they wanted to design. The computer narrowly won, defeating the iPhone™ by one vote. The authors observed the iPad™ was unfamiliar to some children and that others played PC games such as Skyrim™ and likely chose the computer due to comfort and the desire to emulate these games in their own

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

design. Several themes for design emerged from brainstorming, including the themes of games, adventure, scavenger hunts, and exploration.

Session Two: Computer Adventure Game

Building on the ideas from the previous session, the second session's prompt was to design an adventure game for the computer. To accomplish this, the team used the technique Bags of Stuff, dividing into small groups and building low-tech prototypes with various household objects and art supplies (Druin et al., 2001). One child with ASD was hesitant to begin to design, and an adult explained, "There are no wrong answers." The boy asked in response, "Is there a right answer?" As children and adults built models and talked, the researchers took notes in large, simple print and shared the notes with the children (*R3*). To prompt and engage the children, the researchers pulled in the ideas the children had expressed during the informal time at the beginning of the session. For example, one student's response to the question of the day, "What do you think about when you hear the word adventure?" was that he regarded Angry Birds™ as an adventure. This translated into the creation of animals in his design when an adult researcher elaborated upon his Angry Birds™ suggestion (*R1*). As there were three small groups and four researchers (*R2*), one researcher was able to circulate through the room, checking in with and offering new ideas to the small groups, as is the typical in-lab practice. The session resulted in a number of game characters, mainly animals, as well as magazine pictures of people altered by the addition of "googly" eyes. Other main themes included different settings, such as forests, deserts, and oceans, as well as having a "good guy" and a "bad guy."

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Session Three: Narrow the Focus

For the third design session, the design team needed to narrow the focus of the many design ideas and come up with one further developed idea for the game. To achieve this goal, the team used the Mixing Ideas design technique, in which ideas from small groups are physically recombined to create new ideas in larger groups (Guha et al., 2004). Physical artifacts from the previous sessions were fragile and there were difficulties in transporting them geographically. To deal with this issue, the researchers drew iconic representations of the designs on slips of paper. For example, a castle outline represented the elaborately designed 3-D castle from the previous session (See Figure 1). The design team also had access to blank slips of paper on which to continue to draw new ideas (*R4*). At the beginning of the session, the researchers asked the children to recall what they had worked on during the previous session. The researchers then rephrased the response of “Made names of games!” into the reminder that the team had started designing an adventure game. The researchers frequently employed this type of reframing to aid children who had difficulty in following discussions, as well as to engage children who had shorter attention spans. Adult designers offered to write for the children (*R3*) as they had in previous sessions, and elaborated on ideas by drawing on the children’s personal interests (*R1*). Major ideas emerging from the third session were for the adventure game to have different levels, a variety of challenging characters such as wolves, and to add features such as a store where players could purchase upgrades.

Session Four: Develop Game Rules

By the fourth design session, the research team felt that the story and characters in the game were sufficiently refined, but that there were few rules about the game action and how a

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

player would win. To design this action, the fourth session used the storyboards design technique. Storyboarding is useful when attempting to establish the linear progression of a system and to gain direction as to the look and feel of the design (Truong, Hayes, & Abowd, 2006). The researchers drew pictures of each of the levels the team had designed on large sheets of paper and hung them on the walls of the classroom. The children and adults on the team elaborated directly on the storyboards with pens and markers, adding rules, drawings, and modifying the story. The children worked mostly independently of the adults during this session. The adults were willing to write ideas (*R3*), the children could switch to drawing any aspect of the storyboards in greater detail on paper at their desks (*R4*), and the structure of the session was relaxed, with informal conversation between the children and the researchers (*R1*). The children added few new ideas, but instead modified existing ones. For example, the children visually observed that there was no way for a player to access the money system for purchasing upgrades, so they incorporated bags of gold hidden in the game levels. In this way, the storyboards elicited details needed to fill gaps in the action of the game by modifying the existing design rather than continually adding new ideas. Several of the children drew inspiration from sources such as book characters or the Skyrim™ storyline. This caused verbal disagreement among the children, and some ideas were crossed out or changed. At the end of the session, the game was much more complete, with defined navigation through the levels and rules for how to play.

Session Five: Elicit Feedback

Following the Storyboarding session, the researchers programmed a working prototype of the game the children had designed. Since the game was playable, the design team used a design technique called Sticky Noting, which is useful to generate future directions and feedback on

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

more complete designs (Walsh et al., 2009). Here, the researchers asked the children to write their likes, dislikes, and design ideas for the game on sticky notes, with each individual idea on a separate sticky note. The children were comfortable writing their own ideas on sticky notes without the assistance of the adults, with the exception of one boy who preferred that a researcher write for him (*R3*). Pairs of children with an adult worked on the classroom computers or on researcher's personal laptops. As feedback was generated, the adults carried the sticky notes to the board, clustering them to identify commonalities. There was little positive feedback for the first iteration of the game (all positive feedback pertained to "how things look") and dislikes regarding character movement and the player's point of view. Most feedback consisted of design ideas, which included, "castle needs draw bridge," "enemies should move," and "show your money to get better weapons."

Session Six: Fill in Details

By the sixth session, the game still lacked rich detail in certain areas, such as what would happen in the final level once the player crossed the drawbridge to the inside of the castle. The team needed to add new design ideas to complete the game story, and additionally needed agreement about what the ending would be. To accomplish these session goals, the researchers used the Layered Elaboration technique (Walsh et al., 2009). With this technique, a layer of overhead transparency was placed over screenshots of the game areas needing more detail. Each small group drew their game endings on the transparency and then shared their design with a verbal, stand-up meeting. The screenshot and the layer of drawings then passed to another group, which added a layer of transparency and expanded on the existing ideas (See Figure 2). Using Layered Elaboration, the children were able to see and hear their classmates' designs (*R3*), as

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

well as ask each other questions directly during the informal meetings (*R1, R4*). The team agreed to conclude the game's story by creating a choice for the player to battle either the dragon or the evil queen.

Summary Session and Sharing the Design

For the final design session, the class played the last prototype of the game on classroom computers, Smartboard™, and the researchers' personal laptops. Although the children were prompted to look for "bugs" in the game as they played, this time was largely for enjoyment. Additionally during this session, the team constructed an overview of the work they had completed throughout the semester by recalling all the sessions in discussion and writing them on the board (*R3*). Following this review of the design cycle, the children completed a short questionnaire about their experiences designing, with the adults writing for them if requested, as is the normal in-lab practice.

To conclude the partnership, the class visited the researchers' university two weeks after the final design session. After touring the lab space, the child designers talked with graduate students and faculty who visited the lab in response to an email invitation. Informally, each pair of children explained the design process while demonstrating the finalized version of the game on laboratory computers.

Discussion

Using recommendations generated during a previous study with a similar classroom at the same participating school (Foss, et al., 2013), the researchers were able to engage children with learning differences as design partners in Cooperative Inquiry. The following section discusses the efficacy of the four recommendations applied in this study.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Informal Social Time (R1) Affects Designs

The researchers approached the second classroom with planned time for engaging the children in informal social conversation. The researchers were forthcoming about personal details such as positions at the university, interests, and hobbies, and about the design work, and in turn asked the children about their lives outside of the school setting. Overall, the researchers observed that the children in the current study asked fewer questions about steps in the design process or the researchers' personal lives than the children during the previous study, and that they were enthusiastic when sharing personal stories. For the five participating children with anxiety disorders, spending time in open conversation with the adults was likely helpful in fostering the confidence needed to share design ideas. Previous literature supports investing time with children with disabilities prior to design work, as this can foster better partnerships based on mutual trust (Frauenberger, Good, & Alcorn, 2012; Hornof, 2009). These observations indicate that approaching the classroom with planned social time was successful in assuaging the curiosity of the child design partners.

Informal social time during this study resulted in design directions that drew heavily from the children's favorite video game characters and storylines. The researchers and children discussed the videogame *Skyrim*TM, which had recently been released and was played avidly by not only the children, but one of the researchers as well. Characters designed by the children for their game, such as wolves and dragons, shared characteristics with characters from the videogame. The two children with ASD were highly focused on familiar characters: Bowser from the *Super Mario*TM video games, *Angry Birds*TM, and *The Littles* from a series of children's novels. Prior research discusses the difficulty children with ASD experience with imaginative drawing (Low, Goddard, & Melser, 2009) and the need to weigh opportunities for imagination

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

against structured activities (Frauenberger, Good, & Alcorn, 2012). For the two children with ASD, employing known characters into participatory design work, which typically demands high levels of imaginative thought, likely eased challenges of participation. The analysis suggests that informal time with adults helped the children to make these personal connections.

More Consistent Adults, Not Visitors (R2)

During the previous semester with only three adults present, there was not always an adult available to contribute to game designs or act as a leader, creating problems with capturing all the design ideas and transitioning between activities. In reaction, at least four adults were present at each session during the current study. One researcher was typically free to take on a leadership role as needed by writing prompts on the whiteboard, taking notes and photos, injecting new ideas when small groups became stymied, and leading whole group discussions. Having more adults also allowed the researchers to increase focus on individual children by exploring ideas verbally or writing for children.

The three consistent researchers and children were able to successfully elaborate on each other's ideas and were able to collectively arrive at a final game design. The children seemed comfortable with the three consistent researchers in this study, easily sharing personal stories and offering honest opinions about the progress of the design work. However, the fourth adult attending each session was not always the same person. As some adults came to only one session, the children did not get the opportunity to know them and reach the same level of comfort as with the three consistent researchers. A mutual barrier between the rotating researchers and the children was occasionally noticeable during the design work of this study, and similar discomfort has been noted in the literature (Hornof, 2009). The rotating researchers,

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

aware of the lack of comfort for both themselves and children, noted the disconnect they experienced. The attendance of not only a sufficient number, but also a consistent group of adults would likely ease the discomfort for both the researchers and children.

Write and Say (R3), but also Draw and Act Instructions

One of the main approaches employed by the researchers in the current study to ease participation for the class of children with learning differences was to eliminate writing as a requirement for participation. During activities, the researchers took notes on behalf of the small groups, and for activities relying on written feedback, such as Sticky Notes or to complete the questionnaire, the researchers offered to write for the children. However, the children rarely asked the researchers to write for them. Even with the adult design partners offering to do the writing for the children when they requested it, the feedback the children provided via the questionnaire indicated that the class did not enjoy activities where writing was involved. One boy explained on his questionnaire, “Sticky was my least favorite day because there was a lot of writing.” Possibly, the children felt pressure from their peers to decline assistance or the classroom environment encouraged independent writing.

The researchers’ intent in providing written as well as verbal instructions was to communicate using many modalities. The children suggested additional methods for enhancing communication of design ideas. On the questionnaire, five of the 10 children described wanting to communicate their ideas by drawing. One child described, “The day I liked least was the bag of stuff[.] I would rather just draw the thing.” Another child echoed the desire to draw, “Layered Elaborations [was my favorite session] because you can draw a picture on it.” An additional three children proposed other ways to share ideas with the researchers: by typing, by acting out

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

ideas, and by drawing a picture of a single-word prompt. In attempting to broaden the communication strategies when working with children with learning differences, the researchers clearly could have tried numerous other methods to facilitate communication.

While the participation of the teachers and administrators provided the research team with design directions, familiar adults, and behavior management, there were conflicting interests of the two adult stakeholder groups. While not engaging directly with design work, the two teachers expected the same behavioral standards from the children during design sessions as during regular classes, while the researchers attempted to create a friendlier more informal atmosphere during the design sessions. The reluctance on the part of the child partners to allow the researchers to write for them may have been related to the presence of the teachers and the classroom requirement for handwriting.

Factors Affecting Engagement (R4)

The child designers in this study did not display the predicted high level of engagement throughout the design project. During the previous study, the children asked about the details of programming the game repeatedly, used personal belongings in their designs, and asked each other questions during group discussions (Foss et al., 2013). However, during the current study, the child designers were interested in the sessions and eager to share their ideas, but did not show curiosity regarding the technical aspects of the game creation by the programmer, interject during the presentation of group ideas, or show a desire to impact the session synthesis by participating in compiling ideas.

The notable difference in engagement between the two studies can be understood in a number of ways. First, children during the second semester had more frequent disagreement over

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

design directions. Beginning in the first session, the class was almost equally divided as to which platform to choose for their design. Some children incorporated existing characters or games, and this caused other children to point out that this was derivative and to add emphatic notations rejecting their peers' ideas. Disagreements carried through the storyboarding session, where a group of children convinced one boy to erase his own addition to a game level. The remaining two sessions were conflict-free. Examining the children's questionnaire responses, three children indicated conflicting views with their peers. One boy acknowledged arguments during the Mixing Ideas session, while another wrote of the same session, "My least favorite day was Mixing Ideas because I don't like mixing my ideas with other people's ideas." However, the remaining seven children were positive in their evaluation of how well the class worked together, calling their collaboration, "fluent," and "good, well, awesome."

In addition to frequent conflict, the engagement of the children may have been affected by their perceptions of the prototype iterations. Instead of seeing their ideas implemented in high-fidelity prototypes, the researchers spent four sessions iterating the design using low-fidelity techniques. Although the previous study followed this same pattern and the children remained engaged, for the current study's class, the disagreements over design directions may have caused the children to feel as though they were struggling to be heard. Several children contributed the same ideas during more than one session, perhaps to ensure their ideas were incorporated. One boy drew a dragon during the second session, the third session, and wrote sticky notes about the dragon during the fourth session. The questionnaire asked children if they thought their ideas were included. Three children responded negatively, writing that their specific characters were not incorporated, that only two of their ideas were included, and the game reflected their design, "Not much at all."

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Additionally, it is possible that the children during the current study were responding to the researchers' written, stated, and reiterated instructions by not allowing their actions to deviate from what was instructed. Communicating directions in multiple modalities is helpful when designing with children with learning differences, but the researchers failed to foresee the necessity of communicating all options in the same way. As a result, the children may not have understood the variety of participation options the researchers offered. Researchers should ensure a good balance between making sure children with disabilities are supported in understanding design prompts and offering alternative participation in design work.

Conclusions

In two semesters of applying Cooperative Inquiry with a group of children with learning differences, the authors have identified lessons learned and recommendations for future work. The modifications of informal time, a higher adult-to-child ratio, and verbal as well as written instructions uncovered during the first semester's work proved to be helpful during the current study. In particular, the recommendation to communicate using verbal and written instructions could be further expanded to allow broader methods of communication, such as drawing or acting out ideas. The fourth recommendation of anticipating high engagement was not needed as much during this follow-up study, perhaps due to higher levels of disagreement among the children, the researchers' failure to make children feel as though their ideas were heard, because of overenthusiastic instruction, or due to individual differences in the group of participating children.

The authors have found that modified Cooperative Inquiry was effective as an approach for completing a design cycle in two separate classrooms comprised entirely of a population of

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

children with learning differences. Although the current study employed modified Cooperative Inquiry, the modifications pertained to the implementation of the method and not to the philosophies central to Cooperative Inquiry: the empowerment of children to direct their own designs, equalizing power relationships between children and adults, and including children throughout the entire design cycle. Further, including the modifications in other Cooperative Inquiry research is not likely to disrupt or negatively affect the design process.

Limitations and Future Work

Both the population (children with learning differences *vs.* children with typical development) and the setting (classroom *vs.* lab) differed in this study from traditional Cooperative Inquiry. It is thus difficult to determine whether the modifications were needed due to the population, the setting, or both. To isolate the impact of the population, it would be necessary to engage children with learning differences in the laboratory setting while following traditional Cooperative Inquiry practices such as longer design sessions, including a snack time, a long-term partnership with the children, and meeting twice weekly. In this scenario, researchers could observe the efficacy of the modifications without the interference from the change in setting, as in the current study.

In both the initial and current studies, all of the participants were boys ages 11 or 12. While this makes applying findings from one study to the second more direct, it excludes both girls and children of different ages. Of interest in future studies on designing with populations of children with learning disabilities, ADHD, ASD, and anxiety will be broadening ages and including girls as design team members. The authors additionally would like to implement the four recommendations with different populations, such as design teams comprised of a balance

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

of children with and without disabilities, or an entire team of children with disabilities other than of this study.

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IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

References

- Alper, M., Hourcade, J. P., & Gilutz, S. (2012). Interactive technologies for children with special needs. *Proceedings of the 11th International Conference on Interaction Design and Children*, 363-366.
- Benton, L., Johnson, H., Brosnan, M., Ashwin, E., & Grawemeyer, B. (2011). IDEAS: An interface design experience for the autistic spectrum. *Proceedings of CHI '11 Extended Abstracts on Human Factors in Computing Systems*, 1759-1764.
- Bonsignore, E., Quinn, A. J., Druin, A., & Bederson, B. B. (2013). Sharing stories “in the wild”: A mobile storytelling case study using StoryKit. *ACM Transactions on Computer-Human Interaction (ToCHI)*, 20(3), Article 18.
- Brederode, B., Markopoulos, P., Gilen, M., Vermeeren, A. & de Ridder, H. (2005). pOwerball: The design of a novel mixed-reality game for children with mixed abilities. *Proceedings of the 2005 Conference on Interaction Design and Children*, 32-39.
- Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage.
- DeLeo, G., & Leroy, G. (2008). Smartphones to facilitate communication and improve social skills of children with severe autism spectrum disorder: Special education teachers as proxies. *Proceedings of the 7th International Conference on Interaction Design and Children*, 45-48.
- Druin, A. (2002). The role of children in the design of new technology. *Behaviour and Information Technology*, 21(1), 1-25.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

- Druin, A., Bederson, B. B., Hourcade, J. P., Sherman, L., Revelle, G., Platner, M., & Weng, S. (2001). Designing a digital library for young children. *Proceedings of the 1st ACM/IEEE-CS Joint Conference on Digital Libraries*, 398–405.
- DuPaul, G. J., Weyandt, L. L., & Janusis, G. M. (2011). ADHD in the classroom: Effective intervention strategies. *Theory into Practice*, 50(1), 35–42.
- Durrant, A., Hook, J., McNaney, R., Williams, K., Smith, T., Kipling, M., Stockman, T., & Olivier, P. (2013). Design to support interpersonal communication in the special educational needs classroom. *Proceedings of the 12th International Conference on Interaction Design and Children*, 46-55.
- Foss, E., Guha, M. L., Papadatos, P., Clegg, T., Yip, J., & Walsh, G. (2013). Cooperative Inquiry extended: Creating technology with middle school students with learning differences. *Journal of Special Education Technology*, 28(3), 33-46.
- Frauenberger, C., Good, J., & Alcorn, A. (2012). Challenges, opportunities and future perspectives in including children with disabilities in the design of interactive technology. *Proceedings of the 11th International Conference on Interaction Design and Children*, 367-370.
- Guha, M. L. (2010). *Understanding the social and cognitive experiences of children involved in technology design processes*. (Doctoral dissertation). Retrieved from DRUM (<http://hdl.handle.net/1903/11098>).
- Guha, M. L., Druin, A., Chipman, G., Fails, J. A., Simms, S., & Farber, A. (2004). Mixing ideas: A new technique for working with young children as design partners. *Proceedings of the 2004 Conference on Interaction Design and Children*, 35-42.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

- Guha, M. L., Druin, A., & Fails, J. A. (2008). Designing *with* and *for* children with special needs: An inclusionary model. *Proceedings of the 7th International Conference on Interaction Design and Children*, 61-64.
- Guha, M. L., Druin, A., & Fails, J. A. (2013). Cooperative inquiry revisited: Reflections of the past and guidelines for the future of intergenerational co-design. *International Journal of Child-Computer Interaction*, 1(1), 14–23.
- Hayes, G. R., Hirano, S., Marcu, G., Monibi, M., Nguyen, D. H., & Yeganyan, M. (2010). Interactive visual supports for children with autism. *Personal and Ubiquitous Computing*, 14(7), 663-680.
- Hornof, A. (2008). Working with children with severe motor impairments as design partners. *Proceedings of the 7th International Conference on Interaction Design and Children*, 45-48.
- Hornof, A. (2009). Designing with children with severe motor impairments. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2177-2180.
- Kensing, F., & Blomberg, J. (1998). Participatory Design: Issues and concerns. *Computer Supported Cooperative Work*, 7, 167-185.
- Larsen, H. S., & Hedvall, P. (2012). Ideation and ability: When actions speak louder than words. *Proceedings of the 12th Participatory Design Conference: Exploratory Papers, Workshop Descriptions, Industry Cases - Volume 2*, 37-40
- Low, J., Goddard, E., & Melsner, J. (2009). Generativity and imagination in autism spectrum disorder: Evidence from individual differences in children's impossible entity drawings. *British Journal of Developmental Psychology*, 27, 425-444.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Madsen, M., el Kaliouby, R., Eckhardt, M., Hoque, M. E., Goodwin, M. S., & Picard, R. (2009).

Lessons from Participatory Design with adolescents on the autism spectrum. *CHI '09 Extended Abstracts on Human Factors in Computing Systems*, 3835-3840.

Millen, L., Cobb, S., & Patel, H. (2011). A method for involving children with autism in design.

Proceedings of the 10th International Conference on Interaction Design and Children, 185-188.

Moffatt, K., McGrenere, J., Purves, B., & Klawe, M. (2004). The participatory design of a sound

and image planner for people with aphasia. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 407-414.

Ryan, J. B., Hughes, E. M., Katsiyannis, A., McDaniel, M., & Sprinkle, C. (2011). Research-

based educational practices for students with Autism Spectrum Disorders. *Teaching Exceptional Children*, 43(3), 56-64.

Scaife, M., & Rogers, Y. (1999). Kids as Informants: Telling us what we didn't know or

confirming what we knew already? In A. Druin, (Ed.), *The Design of Children's Technology*, (pp.27-50). San Francisco, CA: Morgan Kaufmann Publishers, Inc.

Schuler, D., & Namioka, A. (1993). (Eds.). *Participatory design: Principles and practices*.

Hillsdale NJ, USA: Erlbaum.

Truong, K. N, Hayes, G. R, & Abowd, G. D. (2006). Storyboarding: An empirical determination

of best practices and effective guidelines. *Proceedings of the IEEE Workshop on Distributed Intelligent Systems: Collective Intelligence and Its Applications*, 12-21.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

- Walsh, G., Druin, A., Guha, M. L., Foss, E., Golub, E., Hatley, L., Bonsignore, E. & Franckel, S. (2009). Layered elaboration: A new technique for co-design with children. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1237-1240.
- Walsh, G., Foss, E., Yip, J., & Druin, A. (2013). FACIT PD: A framework for analysis and creation of intergenerational techniques for Participatory Design. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2893-2902.
- Yin, R. K. (2009). *Case study research: Design and methods*. 4th ed. Thousand Oaks, CA: Sage.
- Yip, J., Clegg, T., Bonsignore, E., Gelderblom, H., Rhodes, E., & Druin, A. (2013). Brownies or bags-of-stuff? Domain expertise in Cooperative Inquiry with children. *Proceedings of the 12th International Conference on Interaction Design and Children*, 201-210.

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

Table 1.

Differences surrounding the four recommendations between the previous study and the current study

Recommendations	Previous Study	Current Study
Informal Time (R1)	Little scheduled informal time; spontaneous non-design related discussions	Scheduled informal time beginning each session; personally-focused question of the day
High Adult-to-Child Ratio (R2)	Three researchers present; not always one adult per small group	Four researchers present; one adult per small group; teachers more involved
Verbal and Written Instructions (R3)	Verbal instructions only; No written instructions	Always written instructions; verbal instructions repeated as needed and tied to written
Anticipate High Level of Engagement (R4)	Researchers unprepared for level of engagement	Researchers planned for many types of participation

IMPLEMENTING MODIFIED COOPERATIVE INQUIRY

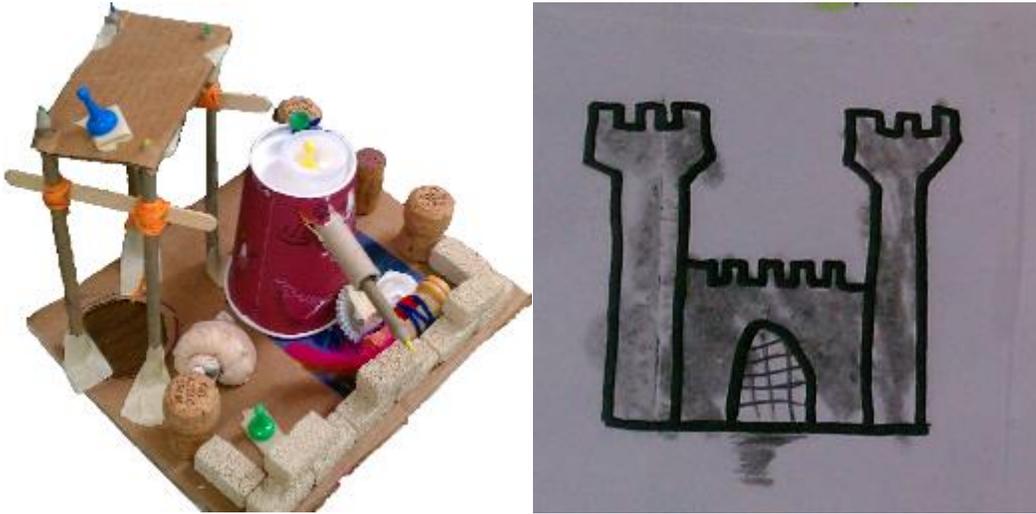


Figure 1: The castle designed by the students during the Bags of Stuff session, and an iconic representation of the castle drawn by a researcher, used during the Mixing Ideas session.

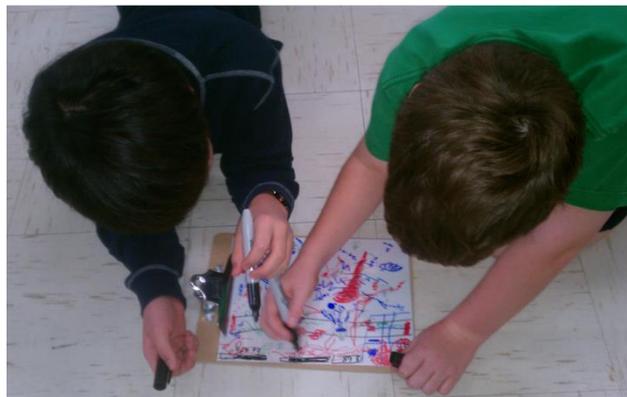


Figure 2: Children elaborating on peers' ideas during the Layered Elaboration design session.