Cooperative Inquiry Extended:

Creating Technology with Middle School Students with Learning Differences

<revised version>

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Abstract

Cooperative Inquiry is a method of developing technology in which children and adults are partners in the design process. Researchers use Cooperative Inquiry to empower children in the design of their own technology and to design technology that is specific to children's needs and wants. As Cooperative Inquiry is continually evolving and expanding, it is important to consider how researchers can extend this inclusive design approach to work with populations of children with disabilities. In a semester-long case study, researchers explored the use of Cooperative Inquiry in a classroom of middle school age boys with learning differences, including mild to moderate autism, specific learning disabilities, and Attention Deficit Hyperactivity Disorder. The participating class of ten boys ages eleven to twelve years old designed a browser-based computer game using Cooperative Inquiry over the course of six design sessions. During the project, the children had overall positive experiences, were able to form partnerships with the adult researchers to develop the game, and researchers uncovered challenges with the sessions. Based on the experiences of all the team members, researchers make recommendations for employing Cooperative Inquiry in special education classrooms. These include adding informal time during the design sessions, maintaining a high adult-to child ratio, giving instructions using many modalities, and planning for high engagement. Through this work, researchers broaden Cooperative Inquiry's applicability to a new population in a classroom setting, and provide guidance for designing with populations of children with special leaning needs in the future.

Introduction

Children with disabilities can use technology to improve their learning experiences (Wehmeyer, Palmer, Smith, Davies, & Stock, 2008), receive social supports (Margalit & Raskind, 2009), or increase ability with literacy and speech development (Zhao, 2007). However, children with special needs are not often involved in the design of the assistive and play technologies that they will ultimately use. Including the end-user during the technology creation and design process is called Participatory Design (Schuler & Namioka, 1993). Participatory Design results in more effective products than traditional design where users are not included during product development (Schuler & Namioka, 1993), and is therefore a valuable approach when creating or modifying technology.

Traditionally, researchers and designers have conducted Participatory Design with children with typical development. There is currently a growing body of work surrounding how children with learning challenges or other special needs (such as developmental or physical disabilities) can become involved in the technology design process (e.g. Brederode, Markopoulos, Gilen, Vermeeren, & de Ridder, 2005; Guha, Druin, & Fails, 2008; Hornof, 2008, 2009). The existing literature shows Participatory Design values applied through varying methods, adapted or created to best approach a particular population of children with disabilities.

In this paper, the authors will explore the application of Cooperative Inquiry, an established method of Participatory Design where children participate as full partners throughout the technology design process (Druin, 1999). Researchers conducted a semester-long case study of the Cooperative Inquiry method in a classroom of middle school age boys with learning differences, autism, ADHD, and anxiety disorders. During the project, the researchers and students designed a computer-based game. The goal of the project was determining what aspects

of Cooperative Inquiry worked well, what aspects worked less well, what modifications researchers need in Cooperative Inquiry with children with learning differences to benefit future work, and to ensuring a positive experience for the child design partners.

Literature Review

Participatory Approaches to Working with Special Needs Populations

Children ages 8-18 years old are using technology at higher rates than ever, with 84% of homes having Internet access, 66% of youth owning cell phones (Rideout, Foehr, & Roberts, 2010), and 55% of children ages 0-8 years having at least once used a mobile device for playing games or using apps (Common Sense Media, 2011). Disabilities such as autism spectrum disorders (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and specific learning disabilities affect a large number of children and adolescents (Centers for Disease Control, 2008, 2012), and given that children with disabilities use technology, designers and researchers need to consider their needs and wants when designing technology. Prior Participatory Design research provides general guidelines for working with populations with special needs.

Altering the design team size and ratio of adults to children. Research has shown that altering the size and ratio of the design team can yield positive results when working with children with differing needs. Hornof (2009) used the design partner model (Druin, 2002) in his work with children with cerebral palsy. Hornof modified the method heavily to adapt to the needs of his design partners, including working with only two children instead of larger groups of children. Benton, Johnson, Brosnan, Ashwin, and Grawemeyer (2011) made similar suggestions in their IDEAS framework for working with children with ASD, which outlined how to best collaborate with children who have communication difficulties. The framework dedicated one adult to providing feedback to and discussion with child participants.

Including adult stakeholders. Prior research has shown that including a broader spectrum of adults in design work with children with special needs is important. Hornof (2008) stressed the importance of building a team of adults in multiple roles around each child. Adults such as caregivers, teachers, and parents comprised these teams. DuPaul, Weyandt, and Janusis (2011) made the same recommendation for working with children with ADHD. Millen, Cobb, and Patel (2011) also discussed the need to consult all adult caregivers surrounding the children, as caregivers can provide insight into the design process.

Flexibility of methods. A number of researchers identified that adhering strictly to a particular method may not be a productive approach to design with special populations. Brederode, Markopoulos, Gilen, Vermeeren, and de Ridder (2005) designed a social interaction game to encourage children with and without learning or physical disabilities to interact. The authors noted that they were unable to employ the Cooperative Inquiry methods due to time constraints. Instead, Brederode et al. used Scaife, Rogers, Aldrich, and Davies's (1997) less intensive informant role, in which children are included at key times during the design cycle. Brederode et al. mentioned specifically their use of a flexible, relaxed observation protocol when gathering feedback about their game design from children with special needs, which took stress off their design informants. They additionally discussed the ability of their informants, in the low-stress environment, to provide feedback on the overall concept of their game based on a prototype.

Guha, Druin, and Fails (2004) presented a framework for incorporating children with special needs at any level of Druin's roles of user, tester, informant, and design partner. In this framework, the design team accommodated the learning, cognitive, or developmental differences of the child partners with varying levels of support, with the goal of allowing the child to

participate fully as a design partner. For example, some children needed an adult present to help with memory or with writing ideas, and other children needed breaks from the design session. Millen et al. (2011) developed methods of including children with autism in the design of technologies such as virtual spaces for collaboration and social skills education. They noted that flexibility in the research approach was important, despite the amount of planning that may have gone into one particular approach.

Assessing individual needs. Even if working with a specific population comprised of a single type of disability, researchers should maintain awareness of individuality. Prior work establishes taking individual preferences and needs into account. Moffatt, McGrenere, Purves, and Klawe (2004) used Participatory Design methods with adults with aphasia in designing a daily planner. The participants were involved throughout the entire design process. In their guidelines, Moffatt et al. (2004) recommend assessing the abilities of each design partner, as individuals can vary greatly. Hornof (2009) mirrors this recommendation, discussing modifying schedules based on individual needs.

Moffatt et al. (2004) recommended gaining practical experience with the population of interest to gain sensitivity and to minimize effects of communication difficulty on research. Hornof (2009) reflected this value when noting his feelings of awkwardness when confronted for the first time with a participant group who had difficulty communicating verbally. When discussing how to best work with children with autism, Benton et al. (2011) included many ways for researchers to enable one individual to participate: provide a visual timeline of the design session, allow extensive discussion about the project, prepare idea prompts for inspiration, align design problems with an individual's interests, and provide a quiet environment.

Summary of prior research. Much of the prior Participatory Design work with children with special needs has occurred in recent years, and as this body of work continues to grow, researchers can begin to understand best practices for design work this population. The examples given above of altering the design team size and ratio of adults to children, including more adult stakeholders, being flexible with planned or established methods, and assessing needs and abilities of children as individuals can lead to appropriate modifications to Cooperative Inquiry or other Participatory Design methods when working with children with special needs.

Cooperative Inquiry: A Participatory Design Method for Children

Participatory Design is a process in which users of a technology are included in the technology design process in an effort to produce products that suit the needs of the user group more appropriately (Schuler & Namioka, 1993). Aiming to give children a democratizing voice in the design of technology for use by children, Druin (1999) and her colleagues pioneered Cooperative Inquiry, an approach to Participatory Design with children. Distinguished from other methods of Participatory Design with children, the techniques and philosophy of Cooperative Inquiry include children as *full partners* in the design processes of children's technology. While researchers and designers often call upon children to serve as users, testers, informants in the design of technology, Cooperative Inquiry engages children as *design partners*, the highest level of involvement that children can have in a design process (Druin, 2002).

Several factors differentiate the role of design partner from other roles identified by Druin (2002). Cooperative Inquiry design teams are composed of adult and child design partners and the ideas of all team members, adult and child alike, are valued equally. In the other design roles, children do not fully partner with adults, but rather use systems, test prototypes, or provide feedback to adults. Design partners are participants throughout the entire iterative design process,

whether creating new ideas, testing prototypes, or working with finished products (Druin, 2002; Guha, Druin, & Fails, 2008). In comparison, other roles engage children at key points in the design cycle. Finally, design partnering is not intended to investigate how technology impacts or educates children; the goal of Cooperative Inquiry is rather to allow children to impact technology (Druin, 2002).

A number of practices support the design method of Cooperative Inquiry. The design team typically consists of six to eight children ages 7-11 and similar numbers of adults (of any age), all of whom participate as team members for a minimum of one academic year. All members of the team, adult and child alike, participate in data gathering (e.g., note taking), prototyping (e.g. building models), and are immersed in technology in the laboratory setting (Druin, 1999). A critical aspect of successful Cooperative Inquiry is idea elaboration, in which adults build on the ideas of children and children build on the ideas of adults in an iterative manner (Guha et al., 2008). Idea elaboration enables children and adults to debrief together after a session (Druin, 2002) as all team members understand how the design ideas evolved, and allows the design team to truly collaborate (Druin & Fast, 2002). In the Cooperative Inquiry method, while adults are typically experts in areas such as computer science, information studies, and education, the children are experts at understanding what it means to be a child today (Druin, 2002).

Cooperative Inquiry Techniques

Within Participatory Design, *techniques* are activities accomplishing the work of the design cycle. Walsh, Foss, Yip, and Druin (2013) define a technique as "a creative endeavor that is meant to communicate design ideas and system requirements to a larger group" (p.1). For

Cooperative Inquiry, there are many techniques available to facilitate designing with children. The following section describes the six techniques used during this project.

Big Paper (Walsh et al., 2009) is a technique in Cooperative Inquiry designed to allow a small group of three to six design partners to work together to express ideas using markers or crayons on a large poster-sized sheet of paper. The spacious drawing area generally allows each design partner to contribute, as combining ideas prior to committing them to the paper is not necessary. This technique does not require the design partners to be experienced at working collaboratively. Big Paper is useful early in the design process as it allows all ideas to be included, and results in many directions for further work, so is appropriate for undefined design problems.

Mixing Ideas (Guha et al., 2004) was originally developed in Cooperative Inquiry as a way to encourage younger design partners (ages 4 to 6) to release ownership of their individual ideas and combine their thoughts with those of progressively larger groups so that the ideas of many children ultimately are combined into one idea. In Mixing Ideas, one child or a small group initially creates low-tech prototypes, drawings, or other design artifacts. Larger groups then physically dismantle and recombine the original artifacts in an iterative process to create a new artifact. Mixing Ideas scaffolds the process of combining ideas on a team for young or new design partners. Mixing Ideas provides increasingly narrow directions for future design work, and so can help to define the parameters of a design.

Storyboarding (Truong, Hayes, & Abowd, 2006) can be used in Participatory Design as a technique to establish a timeline of events in a system as well as to begin to create the initial look and feel of a system. To storyboard a design idea, there must be some parameters already developed (such as the rules to a system or the story of a game). Storyboarding can highlight

holes in the narrative of the system, and can help to decide on the visual components or details of the system. To storyboard, designers create panels using graphics or drawings, sometimes text, to allow the design team to read the sequence of events in a design. This technique is useful independently of the experience level of design partners.

Bags of Stuff (Druin et al., 2001) is a technique within Cooperative Inquiry for low-tech prototyping. Large clear plastic bags filled with arts and crafts materials and household miscellany, and small groups use the bags to build low-fidelity prototypes. This technique requires somewhat experienced design partners, as combining design ideas is a vital part of Bags of Stuff, and understanding how to elaborate and combine ideas takes experience. Bags of Stuff is a beneficial technique for developing new ideas early in the design process and on ill-defined problems, as the objects in the bag inspire creativity and innovation in many directions.

Stickies (Walsh et al., 2009) is a design technique in which design partners interact with a working prototype while writing feedback on a small pad of mildly adhesive note paper. On each note, the design partners write one idea, which can be a "like," "dislike," "design idea," or other category determined to be of interest by the design team. The team then clusters the notes on a wall into similar categories. The clusters serve to alert designers to areas of the prototype that need attention for the next iteration. Stickies is most useful when there is a functional prototype for evaluation.

KidReporter (Bekker, Beusmans, Keyson, & Llyod, 2003) allows child design partners to document a Participatory Design activity using a number of approaches such as photographs, video, and interviews. Children use video cameras and notepads to record their interactions with a system. This technique is ideal for children who may have a difficult time with reading or writing, and allows for a high level of interaction among children and with their surroundings. It

additionally allows for the collection of varied data about the system, and from multiple viewpoints.

Method of the Study

To explore the effectiveness of and needed modifications to the Cooperative Inquiry method when used with children with special needs, the research team engaged in a partnership with a private school for children with learning differences. Researchers felt that working on a real problem and having a tangible result for the participating students was important, rather than risk students feeling as though they were merely part of a research experiment.

The general guidelines inferred from the prior work in this area (i.e., more adults, flexibility, assessing individuals) provided a starting point for the work at the school for children with learning disabilities. The authors held discussions with the administrative staff before beginning design work with the children to establish clear expectations for the researchers, teachers, and for the administration. Additionally, researchers prepared a schedule that would allow three researchers to attend each session, as well as a flexible proposed end-date to depend on the design work and allow for additional sessions as needed. However, researchers did not meet directly with the classroom teachers to discuss individual children, as recommended in the prior literature. Researchers planned the initial session through meetings and email exchanges with administrators and after a visit to the classroom to observe and then meet the students.

During the initial observation session at the school, researchers attempted to frame the design problem presented to the students by developing a topic for design, but without limiting the scope or the platform. During discussion in the classroom with the students and teachers, researchers determined that the class was interested in sports. Researchers also observed the enthusiasm the students held for technology in general. Therefore, the broadly scoped overall

design problem presented to the students was to design a sports game that involved technology. Leveraging existing interests is an approach used in prior research with special populations (Benton et al., 2011). The administration specified that the game should be non-violent, a point that has been made in other research (Tan, Goh, Ang, & Huan, 2009). The initial design prompt was otherwise open-ended, and all other project parameters such as the game rules and visual design naturally arose during the design process.

The Role of the Researchers

Three researchers served as design partners and session leaders throughout the project, with three others visiting as needed to accomplish the session goals. The three lead researchers have backgrounds in early childhood and special education, psychology, and computer science, as well as all having experience working with a design team in the laboratory setting. Planning the design activity for each session took place prior to the school visits during meetings between the three primary researchers. In planning for each session, the three adult team members examined design artifacts and notes collected from the prior session and determined the next step for propelling the design. The two most experienced adult team members led the classroom design sessions jointly. Interacting with the children in small groups was a team effort between the three lead adults and three rotating adults.

Environment and Population

The current project extended the use of Cooperative Inquiry from the laboratory to a classroom of ten 11 and 12 year old boys with ASD, ADHD, learning disabilities, and anxiety. These students attended a private school specializing in educating children with learning disabilities. The school has a 5:1 ratio of boys to girls enrolled, due to a higher identification of boys with learning difficulties (S.E. Shaywitz, B.A. Shaywitz, Fletcher, & Escobar, 1990). The

school's website indicates that the students at the school have a variety of disabilities in math, reading, or visual processing and that the school provides a welcoming environment that encourages each student to meet their full potential.

Researchers asked the administrators to identify anonymously the prevalence of disorders represented within the 10 male students from the participating classroom. Seven students had a learning disability, four had ADHD, and three of the students had mild to moderate ASD. Additionally, five of the students had diagnoses of anxiety disorders. Two of the students were age 11 and the remaining eight were age 12 at the beginning of the project. Two of the students were Asian and the remaining eight were White. Behavior problems appeared minimal throughout the project and the class typically functioned well as a team.

Project

Researchers visited the participating school a total of eight times. One initial session was for researchers to observe the children during their normal class period. Prior to introductions, one child asked, in reference to the researchers, "What are those psychologists doing here?" Researchers therefore wanted to introduce themselves and clarify the idea of working on a technology design project prior to forming design partnerships with the students. The subsequent six sessions focused on the development of the game, using a different Cooperative Inquiry technique during each visit as appropriate to the stage of development of the game. The final session was a reflective session to talk about the experiences that the participants had with the Cooperative Inquiry. Each session lasted one hour and included the 10 children and two teachers (one child was absent during one session). Following the design sessions, the class visited the Human-Computer Interaction Lab at the University of Maryland to play the final version of their game and to share how they designed their game with adults not involved in the process.

Data Collection

The adult team members collected many types of data during the project. Most sessions resulted in *design artifacts*, such as low-tech prototypes or pencil drawings. Researchers took *participant-observation notes* during sessions when able to do so unobtrusively. Immediately following each session, researchers, and occasionally teachers participated in a *debriefing session*, resulting in a compilation of observations about the session. One researcher kept a *journal*, a narrative version of events during each session. Researchers captured *pictures* and *video*, assisted by the child partners during one session. Additional data included the results of a brief *questionnaire* from the final session asking the children their favorite and least favorite sessions, whether they felt their ideas had been included, how the team functioned, and what they would change about their experience. Finally, an interview with the two classroom teachers resulted in an *interview transcript*. Taken together, these documents provided a detailed account of each session, and allowed for triangulation of codes.

Analysis

The qualitative analysis of all of the data was conducted within NVivo (NVivo qualitative data analysis software, 2009), a software tool for qualitative analysis of multiple forms of data. One researcher coded the images, digital scans of artifacts, video, and documents such as researcher notes, debriefing notes, or interview transcripts within the same framework. Themes developed emergently from the data (Strauss & Corbin, 2008), due to researchers not approaching the project with pre-conceived notions of specific findings. Researchers analyzed the data with respect to needed changes in the use of Cooperative Inquiry and for what worked well about Cooperative Inquiry. Following analysis of the data, one researcher presented the findings to the other adult researchers for coding checks. Additionally, the classroom teachers

participated in member checks to verify findings (Creswell, 1998). During the member checks, a researcher presented each of the major findings and asked the teachers if the finding seemed accurate, if anything was missing, and if anything seemed inaccurate. The teachers agreed with the findings.

Design Sessions

Each of the six design sessions began with the team sitting in a circle on the classroom floor. All team members wore nametags; the researchers used their titles and last names (as was required by the school) and wore t-shirts with their lab logo. The adult leader then asked an opinion question relating to the design problem of the day, for example, "What is a cool technology you have used?" Each team member in turn gave their name, age, and responded to the question. The leader then presented the team with a design prompt, or problem to solve through the design activity. Table 1 provides a summary of the six techniques, goal for each session, design prompts, and the specific activities in which the team engaged. At the conclusion of each session, the team met as a whole group to share and synthesize their ideas through presentation and whole-group discussion.

Big Paper

Our first design session began with the prompt to design a sports game that involved technology. Researchers asked the teachers to divide the class into four small groups. Each group of two or three children paired with one adult. Three of the groups began drawing ideas right away, but the fourth group designed their game verbally, with most of the ideas committed to paper by the adult. Another small group had an exchange indicating the limitations they felt researchers might impose upon their designs, "Let's make a swimming chamber!" "But they can't build that." The children also used their own style of shorthand during this session, for

example, writing “p-up” to indicate “power-up.” During the idea synthesis, the children asked each other extensive questions about their designs. The Big Paper artifacts resulting from the session were four large-scale drawings of games with ideas ranging from underwater sports, to hockey played on air by gliding, to lasers attacking players.

Mixing Ideas

During the next session, researchers combined the groups from Big Paper into two groups of five children and two adults, giving each of the larger groups their original designs. The session prompt was to make one new game per group using the original ideas, adding new ideas when necessary. In order to combine ideas, both small groups added an encompassing game layer around their original ideas. For one group, the outside layer was a town with game arenas, and for the second group, the outside layer became space with game planets. Both groups wanted to be able to purchase goods and upgrades (speed, agility, spaceship accessories) and transitioned into the creation of larger worlds, away from the sports theme. To narrow the ideas in the designs, researchers asked the child partners individually to describe the most fun aspects of the game from their perspective. The children gave multiple answers: five children were excited by being in the virtual world (engaging in activities like eating food, visiting their homes), five children discussed upgrades (to strength, the spaceships), and two children described defeating an “ultimate” enemy.

Bags of Stuff

The Bags of Stuff session focused on a design problem outside iterating the class’ game. This allowed the adult programmer on the team time to implement the initial game parameters as dictated during the first two design sessions. The prompt for the Bags of Stuff session was to use the arts and crafts materials to illustrate what design project the children in a second classroom

should undertake in the upcoming semester. The teachers divided the child partners into three small groups, and one adult partner joined each group. Each group had very different ideas: one created a restaurant, the second made a robot, the third created a history-focused time travel game. Commonalities existed among the groups. All of the children played with the objects contained in the Bags of Stuff prior to beginning to design. In addition, each group initially had trouble merging their individual ideas to the point of verbal disagreement. For example, one child with ADS focused on including particular movie characters and his group opposed this. When the adult partners elaborated individual children's ideas to create connections with other ideas, each group was able to produce one idea for their group, with some extra designs included. During this session, the child partners were helpful in cleaning after the design work was completed (as Bags of Stuff can cause a mess).The child partners began calling the adult researchers by name during this session, perhaps indicting their increased comfort level, and the design prompt of planning for their peers was generally forgotten once design work began.

Storyboarding

Although the game had started as a sports-themed game, by this point in the design process it had evolved to a space-themed game. Prior to the session, researchers drew the game in paneled form on large sheets of paper, using as many details as had been established by the team in prior sessions. With the large sheets of paper hung on the walls of the classroom, the design prompt was to write and draw feedback about the story and the visual look of the game on the Storyboards, and then optionally to draw specific artwork for the game on smaller sheets of paper at desks. The child partners moved around the classroom adding their ideas to the paneled drawings, then to their desks to draw, and frequently back to the walls as more contributions occurred to them. Ideas included specifics about how to log into the game, what upgrades should

be available, and that the border to the game screen should be blue in color. In the session, there was one incident of disagreement, with children crossing each other's ideas out. Instead of only corrections and refinements to the Storyboarded ideas as researchers expected, the child partners continued to generate new design ideas.

Sticky Noting

During this session, researchers brought laptops to the school and used the computers present in the classroom to run a prototype of the space-themed game. After explaining the design prompt of providing categorized feedback on the game, researchers offered to help the paired child partners by writing for them. The children preferred to write for themselves, and walked to the whiteboard with their notes to help researchers cluster them and to see how the categories were progressing. The specific feedback requested, that of likes, dislikes, or design ideas seemed to balance the input from the child partners; instead of continuing to add widely to the system, they were able to begin the process of refinement needed to iterate the game past the initial prototype.

One child asked, "Can we make a sequel?" and another wanted to know "Can it be multiplayer?" Other questions concerned technical aspects of the game. "Can it get viruses?" and "Can it make the computer slow?" were some of the questions directed at the adult programmer. Some administrators visited the classroom to observe the game in action, and the child partners seemed engaged as well, with the exception of two children. One of these boys had just gotten braces on his teeth and was eager to talk about it and the other boy seemed focused on movie characters rather than providing feedback on the game.

KidReporter

Based on the feedback from the Sticky Note session, the adult team programmer created a second high-tech prototype of the game for testing in the classroom. The design prompt presented to the team during the KidReporter session was to interview each other about the game and the design process. The child partners had difficulty with the prompt. They were excited about testing another iteration of their game and about using video cameras to interview each other, but quickly ran out of interview questions. For example, one pair of children recorded four videos of the same content, with one boy asking the second what his favorite aspect of the game was and then his least favorite. In the session, there were problems regarding the video cameras- a newly purchased pack of batteries failed and the children had difficulty operating the researchers' personal cell phones offered as replacements. At this point in the design session, researchers changed direction and called the group together to discuss question about the game and to introduce the upcoming field trip. Researchers asked if it was ok with the children to record the discussion, as until this point most of the documentation was in the form of photos and notes. One boy said, "Post it on YouTube and get a million views!" Most of the comments from the child partners were continued design suggestions for the final iteration of the game. The team then voted on the name of the "bad guy" in the game, with "Mr. Guhahahaha" winning the vote. Screenshots of this iteration of *The Game's* home screen and of the avatar selection screen are in Figure 1.

Results

The authors found Cooperative Inquiry to be effective with this population of children with learning differences in the classroom. The authors note the strongest themes emerging from the data in regards to Cooperative Inquiry below. In particular, the researchers found in the participant reaction results that there was a high level of emotional engagement, the child design

partners took ownership of their ideas, one child became disengaged with the project and that the children had difficulty with whole group discussion. The authors additionally present results pertaining to the use of the techniques, as well as about the challenges of shifting Cooperative Inquiry from the lab to the classroom setting.

Participant Reaction

Researchers noticed incidences of engagement, emotional distance, or disagreement among the child design partners in all design sessions. Overall, the children were very excited to participate, making sound effects for the game, asking questions, becoming loud as they worked, and displaying no hesitation when asked to work on a task. The class even took time to draw artwork for the game while the researchers were not present and sent their drawings through the mail to the University for inclusion in the next iteration. When writing a response to the question of what he would change about the techniques, one boy wrote, "I would not change anything. PS: It was awesommme [*sic*]."

Researchers observed that the child design partners developed a strong sense of ownership towards elements of the final design. Researchers explained to the design team on multiple occasions that design work is the result of combined effort and therefore no design belongs to one particular individual; however, the children shared their individual contributions often. After completing low-tech prototypes during the Bags of Stuff session, researchers asked the child partners to move their design to the front of the room to synthesize ideas. One child took his group's design saying, "I will carry it because it is my idea." During the KidReporter session and the field trip to the University of Maryland campus, the child design partners often pointed out their individual contributions, such as drawings included in the final game, or that they had come up with the idea for a section of the game. In the written responses to the

questionnaire, only one boy felt that the game did not incorporated his ideas, “Because I didn’t see any of my drawings.”

During three sessions in particular, an individual child with ASD appeared disengaged. This design partner explained his disengagement during the Mixing Ideas session by stating, “I have lots of real-life things on my mind.” In response, the adult leader allowed him to participate at his own pace, rather than attempting to direct him in the same way as the rest of the class. This less structured approached seemed to work well, as he did have ideas at the end of the session. In a second instance during the Storyboarding session, the same child began to write ideas that his classmates did not agree with. Another child crossed out his classmate’s contribution and wrote other ideas below. Researchers had not previously experienced such clear rejection of ideas during Cooperative Inquiry sessions and in this instance were not prepared with a standard reaction. Researchers asked the entire design team to leave all ideas as written, and to add other ideas if there was disagreement. These two incidents, combined with being outvoted for the name of the “bad guy,” were enough to cause this child to disengage from the game. There were few other arguments or disagreements during the sessions that the child partners could not resolve on their own.

Technique

Researchers noticed a number of challenges with the individual techniques, and in particular, with the techniques used during the first three sessions with less defined design problems and the child partners were new to designing. During the Big Paper session, there was an initial reluctance in some of the small groups to begin to draw. During our Mixing Ideas session, researchers observed a similar problem with the unfamiliar task to combine ideas. While engaging in Bags of Stuff, the children again felt as though they had less direction than they

needed when initially beginning to build low-tech prototypes. During these initial sessions, the experienced adult design partners were present to facilitate and elaborate on ideas, and the child design partners were enthusiastic, seemed to enjoy themselves, and did not exhibit unexpected amounts of frustration.

Two other sessions, Storyboarding and KidReporter, also had challenges, but for different reasons. During the Storyboarding session, researchers accidentally placed the paneled outline of the game on the wall in the wrong order, greatly confusing some of the children and the researchers. Additionally, the children unexpectedly continued to generate design ideas as they had during the previous two sessions rather than focusing on narrowing their ideas as researchers anticipated during the session. For the KidReporter session, the camera difficulties caused one boy to write, "The cameras had something wrong with it [*sic*]" and to suggest to researchers, "Have the cameras fully charged" as what he would change about the project. In analyzing the footage captured during KidReporter, there are15 videos ranging from a few seconds to three minutes for the hour-long session, which is not surprising considering the difficulties experienced during the session.

When asked their favorite session at the end of the design cycle, six out of nine present children wrote they liked the Bags of Stuff session the most. For example, one boy wrote, "My favorite day was when we did Bags of Stuff because I could build things." In contrast, the children reported that the least favorite session was Stickies, with three out of the nine children present reporting that they liked it the least. One boy wrote, "My least favorite was when sticky notes happened because it was kind of boring." During this session, adult partners were present in the room and moved from pair to pair of children, offering to write for them; however, most of the children preferred to work with each other without the help of the adults. Another least

favorite session was KidReporter, with two out of nine children stating this was their least favorite.

Lab to Classroom Shift

Researchers found a number of challenges that stem from adjusting Cooperative Inquiry from the lab setting to the classroom setting. These challenges pertain to the length of time available for the sessions, the high level of personal engagement with the researchers, number of researchers available, and the physical affordances of the classroom.

Concerning the length of session, each session in the classroom setting lasted one hour, and researchers found that this was not enough time to address all of the segments of the design session including the introduction to the design problem, the design activity, and the discussion of the major ideas emerging from the session. Additionally, the limited time made in-situ adjustment difficult when the child design partners became more or less engaged, such as during the KidReporter session.

As the number of visits to the participating school increased, researchers found the children asking questions and engaging with researchers more often; however, there was no designated time in the design process to allow for informal discussion. The children asked where the adults were from, about their roles at the University of Maryland, and other questions not pertaining directly to the development of the game. They also seemed very interested in parts of game development that took place without them, asking many questions about the programming or technical aspects of implementing the game.

On occasion, it was necessary for researchers to leave their initial small group and move around the room to other groups due to the limited number of researchers present. This lead to a lack of true design partnership between children and adults during some sessions, as an adult

design partner was not present with each group at all times to contribute to the design idea and elaborate with the child design partners throughout the entire design.

The classroom was somewhat limited as a physical design space as it was crowded with desks and other materials. During sessions where the team needed floor space, as in Big Paper, Mixing Ideas, or Bags of Stuff, there was less space than would be desirable, and starting the sessions required often noisy and messy pushing aside of desks. However, other sessions used wall space, such as Stickies and Storyboarding, and for these sessions, the design team sat in the desks present in the classroom. The children asked to use classroom materials as design props. For example, they wanted to use personal supplies of scissors and markers during some sessions, and one child had a computer printout of cartoon characters that he wanted to use as artwork for the game. In the laboratory setting, the design team does not have access to personal supplies, so the incorporation of supplies and other personal belongings is unique to the classroom setting.

Researchers found that it was easy for the children to become engaged in thoughts not pertaining to the topic when participating in group discussions. For example, when interacting with a researcher during the KidReporter session, one boy said, “I lost my train of thought….wait, I found it.” One classroom teacher also mentioned the ease with which the children could become off-task in general as an aside to a researcher; this was not an issue unique to our design sessions.

Discussion

Empowerment

There are a number of established difficulties and benefits for children when they commit to participate in the capacity of design partner. Children can experience a sense of frustration when they see that their design ideas are not included, or they can feel a sense of empowerment

when they understand that adults are taking their opinions seriously, feeling that they have the ability to make a difference (Druin, 2002). Frauenberger, Good, and Alcorn (2012) discuss that one of the benefits of using Participatory Design methods with children with disabilities is the sense of ownership and empowerment that children feel as a result of their contributions to a project. Researchers saw incidences of empowerment as well as frustration during our sessions in this project. The authors interpret the frequent statements of contribution from the participating children as evidence of empowerment, as the children were able to see their ideas realized in a tangible way within the game.

Design Partner Relationships

Incidents of disagreement that are not quickly resolved are unusual in the lab setting with children with typical development. It is possible that due to the classroom environment there were team dynamics that researchers were unaware of, such as carryover from prior events, or that due to the learning and social differences of the participating schoolchildren they are less able to resolve differences of opinion. Students with ADHD are less adept at resolving conflict (Antshel Hargrave, Simonescu, Kaul, Hendricks, & Faraone, 2011), and children with autism can find social interactions more difficult during Participatory Design activities (Frauenberger, Good, Alcorn, & Pain, 2012). However, the disagreements during this study, while more frequent than in the lab setting, were not exacerbated by Cooperative Inquiry. Researchers drew themes resulting from each session rather than focusing on the individual conflicting ideas through idea synthesis as well as elaborated on ideas, and this aided the children in moving past their individual game visions and into collaborative game design.

The shorter time available to researchers for conducting Cooperative Inquiry sessions in the classroom meant that there was very little available time for researchers and child design

partners to get to know each other as called for in the literature (e.g. Benton et al., 2011; Moffatt et al., 2004). For instance, researchers simply eliminated the traditional "snack time," during which general conversation takes place in the lab setting. The value of this time became clear when implementing Cooperative Inquiry in the classroom when the child partners began asking the researchers questions not pertaining to the game design, demonstrating a desire for more personal level knowledge of the adult design partners.

In the lab setting with a nearly 1:1 ratio of adults to children, researchers would have one researcher stay with each small group of children, but this was not possible in the classroom. Although during initial planning researchers thought that a minimum of three researchers would be sufficient, it proved difficult to design partner with the children due to needing one adult to lead parts of the session. The literature surrounding design work with children with special needs recommends involving higher ratios of adults (Benton et al., 2011; Hornof, 2008), and this was borne out in the current study.

Session Challenges

The challenges the design team experienced during the first three sessions are likely due to the unfamiliar concept of design partnering for the participating classroom, as well as to the undefined design space early in the design cycle. As experienced design partners, the adults facilitating the Cooperative Inquiry method in the classroom attempted to structure the progression of the sessions in such a way as to begin with techniques requiring little design experience, moving into techniques to which experienced child partners respond better (Walsh et al., 2013). Millen et al. (2011) discuss that children with autism need specific directions and examples when presented with ambiguous design problems, so poorly defined problems might be problematic for these children. To alleviate some of the confusion of the initial sessions,

perhaps researchers should devote more time to introducing the concepts of Cooperative Inquiry in an initial session and provide instructions more clearly.

In Cooperative Inquiry, the development of design partner relationships calls for changes to typical adult-child interactions, such as asking children not to raise their hands before speaking, using first names instead of titles, and asking adults to wear informal clothing (Druin, 2002). In this project, the children became off-task mainly not during the small group design activities, but rather when it was necessary for the entire design team to participate in discussions, during which researchers encouraged unrestricted speaking. For classroom projects with children with learning differences, retaining the hand-raising boundary present in the school setting might facilitate successful design partnering during whole-group discussions, as it may be difficult for some children to interject comments appropriately.

Conclusions

In the past, researchers have mainly used Cooperative Inquiry with children with typical development and in a laboratory setting. This project broadens the applicability of Cooperative Inquiry to populations of children with learning differences and the classroom setting. Based on our experiences at the participating school, the authors make the following recommendations for using Cooperative Inquiry with children with learning disabilities, ADHD, and mild to moderate ASD in a classroom setting.

Informal Time

The children were extremely interested in us as researchers and desired time to talk with us informally about the project and more personal subjects. The authors recommend scheduling design sessions to last an hour and thirty minutes. This longer time span should include a scheduled informal time with no design work when the design teams can socialize. When

working with children with typical development in the lab, researchers build informal time into the session structure by sharing snack and informal discussion prior to engaging in design work, which aids in establishing solid relationships between child and adult team members. For all child design partners, and especially for those on the autistic spectrum, the authors believe that this additional informal time might serve to allow adults to get to know the children better, as well as allow the children to become more comfortable with the adults and the team as a whole. The authors acknowledge that the amount of time recommended may make conducting design session during school hours difficult, and that perhaps researchers may have to conduct afterschool design sessions.

High Adult-to-Child Ratio

The authors found that full partnership at the school was difficult due to the three consistent researchers having to divide their attention between as many as five groups of children. A higher adult-to-child ratio would ensure full partnership in that adults would be present at all stages of the design process to contribute, rather than dividing their attention by rotating through groups. Having consistent adult participation may help to avoid such problems as difficulties writing and spelling, as the adult is available to write for the group and to ensure clarity. Additionally, in order to share ideas from children who may not be adept at verbal communication, the consistent adult researcher can assist in presenting ideas to the larger group. This may also alleviate some of the difficulties the children experience in remaining on-task during whole-group discussions.

Verbal and Written Instructions

Given that some of the design sessions incorporated techniques unfamiliar to the students, the design techniques should be presented as simply as possible, with written as well as

auditory directions. The classroom teachers echoed this finding. As one teacher said, "We have a group of kids where their auditory processing is very well- they have difficulty with processing things auditory. So you always have to write something down, and also have somebody repeat back; have one of the students repeat back." This insight, to write and state instructions repeatedly, is different from design work with children with typical development in the laboratory setting, where the child partners do not often need repeated or written instructions. By writing instructions as well as repeating them aloud, students with learning disabilities could be better supported with their difficulty recalling information (Brigham, Scruggs, & Mastropieri, 2011) and thus may be more successful in the design activities.

High Engagement

The children working on this project were heavily involved in the development of a single product where they were completely responsible for all of the design decisions. The students at the school showed engagement, a desire to participate in all aspects of the design process, and were able to see the results of their design work relatively quickly, which they found empowering. Preparation for more immersive involvement for the child partners can improve their experiences, as seeing their contributions embodied in the team design was a positive outcome of this project. During sessions, adult design partners should consider placing more responsibility for the outcomes on the child design partners by allowing them to cluster sticky notes by theme or synthesize the session outcomes, which child partners in the laboratory setting do not generally do. Additionally, rapid iterations incorporating recent design work can keep child partners engaged.

Limitations and Future Work

The authors recognize that there are limitations in this project. Ten children may seem to be a small population, however, 10 children is somewhat larger than a typical yearly in-lab design group, which includes six to eight child designers. This case study was qualitative in nature and it was therefore not the goal to produce statistically generalizable results. Rather, the authors believe that this in-depth case study will be able to inform others who are interested in transferring the Cooperative Inquiry method into a design situation with children with learning challenges.

Researchers should implement the recommendations identified by this project for changes to Cooperative Inquiry techniques more widely to learn their applicability to various special needs populations comprised of mixed ages and genders, as this project included only boys very close in age.

Researchers will continue this work with another classroom at the same private school with a similar group of children to test the above modifications. Researchers will apply the recommendations for changes uncovered by the current project to the second classroom, as well as the recommendations from the prior literature, including meeting directly with classroom teachers prior to beginning design work. It is the hope of the authors that the recommendations when implemented with a second classroom will result in an improved experience for the child partners, and that the replication of the study will additionally endorse the utility of minimally modified Cooperative Inquiry as a viable method when creating technology with children with learning differences.

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Table 1
Structure of the Six Design Sessions

Technique	Purpose	Prompt	Activity
Big Paper	Generate initial design directions	Design a sports game with technology	Drawing and writing design ideas on large sheets of paper
Mixing Ideas	Combine multiple design directions	Mix ideas from last week into one game	Physically recombining artifacts from Big Paper using scissors and tape
Bags of Stuff	Allow a break from project	What should the class next semester design?	Using arts and crafts supplies to plan for age-mates' design project
Storyboarding	Refine ideas, visual design feedback	Write and draw changes to the game on the storyboards	Annotating paneled drawings of the game's story
Sticky Noting	Generate feedback on prototype	Play the game and write likes, dislikes, or design ideas down	Writing prototype feedback on notes then clustering notes by theme
KidReporter	Generate data, gather final feedback	Interview each other about the game and design process	Students interviewing each other about the game using video cameras

Figure 1. Game screenshots demonstrating the layout of the home screen of "The Game" and children's avatar artwork. Although the game originally began as sports-themed, through the iterative Cooperative Inquiry process, the overall motif became that of space.