Cooperative Inquiry Design Techniques in a Classroom of Children with Special Learning Needs

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Abstract

Cooperative Inquiry is a method of developing technology in which children and adults are partners in the design process. Cooperative Inquiry is used 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, we need to consider how researchers can extend this inclusive design approach to working with populations of children with developmental, behavioral, or learning disabilities. In a semester-long case study, we explored the use of Cooperative Inquiry techniques in a classroom setting with middle school age boys with special learning needs, including mild to moderate autism, dyslexia, and attention deficits. The participating class of 10 boys ages 11-12 designed a browser-based computer game using Cooperative Inquiry techniques over the course of seven design sessions. Findings include that Cooperative Inquiry techniques require few modifications for use by the population of children with special learning needs. The recommendations to employ Cooperative Inquiry in a special education classroom include modifications to session structure and planning, adding informal time during the sessions, maintaining a high adult-to child ratio, giving instructions using many modalities, and planning for high engagement. Through this work, we believe that Cooperative Inquiry's applicability is broadened to a new population in a classroom setting, and can be used to design more effective technologies for populations of children with special leaning needs in the future.

Introduction

Technology has the potential to be used effectively with children with disabilities to improve their learning experiences (Wehmeyer, Palmer, Smith, Davies, & Stock, 2008), provide social supports (Margalit & Raskind, 2009), or increase ability with literacy and speech development (Zhao, 2007). The use of technology for children with special needs is still being explored and the efficacy of the use of technology is still being verified in many areas, such as educational and home settings. However, much of the assistive and play technology available for use with children with special needs is not designed by the children who will ultimately be the users of the technology. This type of design, where the end-user is a part of the design process, is called Participatory Design. Participatory Design results in more useable, learnable, and more effective products than traditional design where users are not included during product development.

Traditionally, when partnering with children in the technology design process, work has been done with typically developing children and in varying settings such as classrooms (Kelly, Mazzone, Horton, & Read, 2006; Rode, Stringer, Toye, Simpson, & Blackwell, 2003) or laboratories (Druin, 2002). However, currently there is a growing body of work surrounding how children with learning challenges or other special needs can become as involved in the technology design process as typically developing children (e.g. Brederode, Markopoulos, Gilen, Vermeeren, & de Ridder, 2005; Guha, Druin, & Fails, 2008; Hornof, 2008; 2009). In this paper, we will explore the application of the techniques of Cooperative Inquiry, a subset of Participatory Design where children are considered full partners throughout the technology design process, in a classroom of middle school age boys with learning and developmental differences.

Researchers used Cooperative Inquiry techniques for including children as design partners throughout the entire design cycle of a software system, which lasted the duration of a semester at a private school for children with learning challenges. The goal of the project was to determine what techniques work well, what techniques work less well, and what modifications should be made during the design process to techniques to ensure a positive experience for the child design partners. We hoped to broaden the applicability of Cooperative Inquiry to a new population as well as to ensure a positive experience for the participating students.

Literature Review

Population

The children in the participating classroom had a mix of learning disabilities, ADHD, and autism spectrum disorders. Our basis for modifying Cooperative Inquiry techniques is therefore based on a review of the literature with respect to these disabilities and disorders. In children ages 6-17, the overall prevalence of learning disabilities between 2006 and 2008 was 5% (Centers for Disease Control and Prevention, 2008). According to the same report, Attention Deficit Hyperactivity Disorder (ADHD) affected 5% of children of age 6-17 for the same period, while the comorbitity rate between ADHD and learning disabilities was 4%. Autism can affect communication, socialization (similar to ADHD), and interests (Ryan, Hughes, Katsiyannis, McDaniel, & Sprinkle (2011). Among 8-year-old children included in a survey by the CDC, the overall prevalence rate of ASD is about one child in every 110 (CDC, 2012). These disabilities affect a large number of children who are using technology, therefore we need to consider their needs and wants in the design of technology.

Research provides guidance about difficulties that children with these difficulties face and how we might help them overcome those difficulties. As described by Brigham, Scruggs, and Mastropieri (2011), students with learning disabilities encounter difficulties in science learning due to processing differences affecting the students' abilities to recall information, will experience more behavioral difficulties, and will be less successful in acquiring information in the classroom setting through verbal, written, or media presentation. One of the major recommendations by Brigham et al. is that students with learning disabilities learn in a more hands-on way. Students with ADHD frequently are less apt with social, academic, and behavioral abilities (Antshel, Hargrave, Simonescu, Kaul, Hendricks, & Faraone, 2011). In a classroom setting, teachers can help students by periodically reminding the student of positive behaviors to emulate, changing the length or content of assignments, and building a team of adults around the needs of each child with ADHD (DuPaul, Weyandt, & Janusis, 2011). This information about children with ADHD, autism, and learning disabilities was borne in mind as we considered how to modify Cooperative Inquiry for use in their classroom.

Cooperative Inquiry: A Participatory Design Method

Participatory Design is a process by which users are included in the design process, from conceptualization to final product testing, in an effort to produce technologies that better suit the needs of the user group (Schuler & Namioka, 1993). Participatory Design was initially conceived for use with groups of adults. Cooperative Inquiry, a sub-set of Participatory Design with children, is described in Druin (2002). In Cooperative Inquiry, child and adult team members work together as design partners. This model allows for the inclusion of children as co-designers; taking on roles as integral to the design work as adult partners. Druin and colleagues contend that the most important aspect of Cooperative Inquiry is idea elaboration, where adults build on the

ideas of children, and children build on the ideas of adults. This balance is difficult to achieve. Therefore, Druin makes recommendations for fostering the possibility of true partnership. Druin notes the need for both children and adults to contribute to data gathering for low-tech prototypes (e.g., note taking, contributing to brainstorming, building models) to guide the design of high-tech prototypes, and for children and adults to debrief together after a session.

Prior work with Cooperative Inquiry techniques has been conducted in the University of Maryland's Human Computer Interaction Lab (HCIL) with an intergenerational team including mixed-gender and age population of children (ages 6-11) recruited through social networks from local public and private schools, as well as adult team members. This research group, known as Kidsteam, develops new technologies such as web pages or applications through partnerships with internal university researchers or industry such as the National Park Service.

Participatory Approaches to Working with Special Needs Populations

Prior research applies to working with populations with special needs using many methods and techniques of design, falling within the Participatory Design approach with children. There are general guidelines that can be inferred from the prior work, as described below, and which researchers used in the current study to consider how to modify Cooperative Inquiry for use with a population of children with special needs.

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 methods heavily to adapt to the needs of his design partners, including working with two children at a time instead of larger groups of children. In their IDEAS framework for working with children

with autism spectrum disorders, Benton, Johnson, Brosnan, Ashwin, and Grawemeyer (2011) outline how to best collaborate with children who have communication difficulties. The framework includes a one-to-one adult to child ratio, with one adult providing feedback and discussion with child participants.

Prior research has shown that including more adults in design work with children with special needs is important. In his earlier work, Hornof (2008) stressed the importance of building a team of adults around each child with special needs who is working on a design team. These teams are comprised of adults such as caregivers, teachers, and parents. DuPaul et al. (2011) make the same recommendation for working with children with ADHD. Millen et al. (2011) discuss the need to consult all adult caregivers surrounding the children, as caregivers may be able to provide insight into the design process. In the current project, researchers included teachers and administrators who were familiar with the children throughout the design cycle.

A number of researchers have 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 note that they were unable to employ the Cooperative Inquiry due to time constraints. Instead, Brederode et al. utilized Scaife et al.'s (1997) less intensive informant role, where children are included at key times during the design cycle. Brederode et al. mention 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 discuss 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 (2008) present a framework for incorporating children with special needs at any level of Druin's levels of involvement of user, tester, informant, and design partner. In this framework, the learning, cognitive, or developmental differences of the child partners are accommodated by the design team 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 throughout the design process to help with memory or with writing ideas, and other children needed breaks from the design session. This framework is based on design sessions in a laboratory setting, and does not include provisions for working with a design team comprised fully of children with learning differences but rather incorporating the special needs of one child into a design team. Millen, Cobb, and Patel (2011) are developing methods of including autistic children in the design of technologies such as collaborative virtual spaces for collaboration and social skills education. They note that flexibility in the research approach is important, despite the amount of planning that may have gone into one particular approach.

In working with a specific population comprised of a single type of disability, there is still a great amount of individual variation. Taking individual preferences and needs into account is established in prior work. Moffatt, McGrenere, Purves, and Klawe (2004) used methods similar to Cooperative Inquiry with adults with aphasia in designing a daily planner. While this study was with adults and the participants were not considered by Moffat et al. to be full design partners, the users were involved throughout the design process. In their guidelines, Moffatt et al. recommend assessing the abilities of each design partner, as individuals can vary greatly. This is mirrored in Hornof's (2009) recommendation to modify timeframes depending on individual needs. Moffatt et al. (2004) also recommend gaining practical experience with the population of interest to gain sensitivity and to minimize effects of communication difficulty on research. This

consideration is likewise reflected in Hornof (2009), who noted his feelings of awkwardness when confronted with a participant group who had difficulty communicating verbally. Benton et al. (2011), when discussing how to best work with children with communication difficulty, include providing a visual timeline of the design process, extensive verbal discussion about the project, and providing idea prompts if children are unable to generate design ideas on their own, providing design tasks that appeal to the individual child's interest, and a quiet environment.

Summary of prior research. Much of the prior work with Cooperative Inquiry with special populations has modified the methods that are accepted as best practices. The examples given above of altering the design team size , including more adult stakeholders , being flexible with methods, and assessing needs and abilities of child design partners prior to beginning design work can lead to appropriate modifications to Cooperative Inquiry or other methods when working with children with mixed abilities. In this project, we expand the use of Cooperative Inquiry techniques in a classroom setting with children with learning differences.

The general guidelines inferred from the prior work in this area provided a starting point for the work at the school for children with learning disabilities. Researchers 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. Researchers additionally prepared a schedule that would allow for two factors: for many researchers to attend each session, as well as a proposed end-date that could be flexible, depending on the design stage to 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. Meetings with administrators and email exchanges were considered sufficient for planning the

initial session, as we intended to create a design team of all the children in the classroom, rather than address the needs of individual children.

Cooperative Inquiry Techniques

There are many techniques used in Cooperative Inquiry (Walsh, Foss, Yip, & Druin, in submission). Techniques are design activities that support the varying stages of the design cycle. For this project, researchers chose to use the most appropriate technique for the design goal of each session, aiming to complete a design cycle of an Adobe™ Flash-based game. Adobe Flash was used to provide animation to the game. Overall, researchers used six techniques common in Cooperative Inquiry and Participatory Design. These techniques were chosen for the appropriateness to the stage of the design cycle and to the goals of each session to move the design of the game forward. The following is a brief description of each technique that the researchers employed at the participating school.

Big Paper (Walsh et al., 2009) is a technique designed to allow a small group of 3-6 design partners the freedom to express ideas using markers or crayons on a large 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.

Mixing Ideas (Guha et al., 2004) was originally developed as a way to encourage younger design partners (age 4 to 6) to release ownership of their ideas and combine their contributions with those of a small group. In Mixing Ideas, low-tech prototypes, drawings, or other design artifacts are initially created by one child or a small group of children and then physically dismantled and recombined iteratively in groups to create a new artifact. *Storyboarding* (Truong, Hayes, & Abowd, 2006) is used to establish a timeline of events 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 the system or the story of the game. Storyboarding can highlight holes in the narrative of the system, and can also be used to decide on the visual components of the system. To storyboard, designers create panels using color and graphics or drawings to allow the design team to read the sequence of events in a design. *Bags of Stuff* (Druin et al., 2001) is a technique for low-tech prototyping. Large clear plastic bags are filled with arts and crafts materials and household miscellany. These supplies are then used to create low-fidelity prototypes. Bags of Stuff is a beneficial technique for developing new ideas early in the design process. *Stickies* (Walsh et al., 2009) is a design technique that generates feedback on the design after a working prototype is established. Design partners are presented with the prototype and a pad of sticky notepaper. On each note, the design partners write one idea, which can be something that they "like", "dislike", "design idea", or other category determined to be of interest by the design team, about the prototype. These notes are clustered on a wall into categories. For example, the design team often has design ideas about what sounds should be in a prototype. Similar ideas are clustered together, alerting the designers to the need to address the concerns with larger clusters. *KidReporter* (Bekker, Beusmans, Keyson, & Llyod, 2003) allows child design partners to be responsible for the documentation of a session by using a number of methods such as photographs, video, and interviews. Child design partners are given video cameras and notepads, and are allowed to interact with the 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 in a design session. It additionally allows for the collection of different kinds of data about the system under examination, which strengthens the researcher's ability to understand the needs of the user group by providing data for comparison against other collection methods.

Design Methods

To explore the effectiveness of Cooperative Inquiry techniques with a population of children with learning differences, and how the techniques would need to be modified for this population, the research team felt that having a tangible result for the design team was important. Working on a problem from the beginning of the design cycle would allow researchers to mimic closely how Cooperative Inquiry has been used successfully in the past. In addition, it is more impactful to have the participants work a real-world product rather than risk the possibility that our partner school and the participants would feel as though they were merely part of a research experiment.

During an initial observation session at the school, we attempted to limit the design problem presented to the students by developing a topic for design, but without limiting the scope or the platform. During discussion with the students and teachers, we determined that the class was interested in developing a sports game on the computer. We also observed the enthusiasm the students held for technology in general. Therefore, our 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 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.

Environment and Population

The current project expands the use of Cooperative Inquiry from the laboratory to a classroom of ten 11 and 12 year old boys with developmental, learning, and behavioral disabilities. 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 ten students from the participating classroom. All ten have a learning disability, six have ADHD, and two of the students have autism. Behavior problems appeared minimal throughout the project and the class typically functioned well as a team.

Project

Our team visited the participating school a total of eight times. One initial session was for researchers to observe the children during their normal class period and to introduce both themselves and the idea of working on a technology design project. 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 design process. Each session lasted one hour and included the ten children and two teachers. One of the participating children was absent during one session. Following the design sessions, the class visited the Human-Computer Interaction Lab to play the final version of their game and to share how they designed their game with adults not involved in the process.

Each design session included a specific prompt given to the design team, which the design team approached using one of the techniques. The prompts were specific questions or problems to solve. Throughout each session, the children and researchers worked together to use the technique to come up with a solution to the day's prompt.

Data Collection

Many types of data were collected during the project Most of the sessions resulted in *design artifacts*, such as low-tech prototypes, video interviews, 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 a session. Adult and child design partners captured *pictures* and *video.* Finally, an interview with the two classroom teachers resulted in an *interview transcript*. Taken together, these documents provide a detailed account of each session, and allow 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. These codes were developed emergently from the data (Strauss & Corbin, 2008), due to researchers not approaching the project with pre-conceived notions of specific findings. However, the data was analyzed with respect to needed changes in the use of our techniques and

for what worked well about our techniques. Following coding of the data, the findings were presented 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 all of the findings.

Results

We found Cooperative Inquiry to be effective this population of children with special learning needs in the classroom. The strongest codes regarding changes to Cooperative Inquiry which emerged from the data are noted below. We found in the participation results that the child design partners took ownership of their ideas, and also that there was a high level of emotional engagement on the part of the child design partners. We additionally present findings pertaining to the techniques themselves, as well as about the structure of the design sessions. These findings indicate that minimally modified Cooperative Inquiry is appropriate for use in classrooms of populations of children with special learning needs.

Participation

There was a strong sense of ownership of elements of the design felt by all of the child design partners. Researchers explained to the design team on multiple occasions that design work is the result of combined effort and therefore no design belongs to anyone individually, However, the children were often eager to share their individual contributions. During the KidReporter sessions 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. With experienced child design partners who participate on the lab team, there is more of an understanding that the end design is the result of combined effort.

The design sessions at the school were emotionally charged. Noticeable during all of the design sessions were incidences of engagement, emotional distance, or disagreement among the child design partners. Overall, the children were very excited to participate, and made sound effects for the game, asked questions, became loud as they worked on the game, and displayed no hesitation when asked to work on a task. On occasion, an individual child would appear disengaged, not talking or contributing. One design partner once explained his disengagement, stating, "I have lots of real-life things on my mind." At times such as this, researchers allowed children to participate at their own pace, rather than attempting to direct them. This less structured approached seemed to work well. Additionally, while there were very few arguments among the participants during the design sessions, there was enough disagreement to cause one participant to disengage from the game, feeling that his ideas had not been included in the final design. During the storyboarding session, the children added ideas to the bottom of each story panel in pencil. When the same child began to write ideas that his classmates did not agree with, another child crossed out his contribution and wrote other ideas below. Incidents of disagreement that are not quickly resolved are unusual in the lab setting with typically developing children. 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 that they are less adept at resolving conflict. Antshel et al. (2011) note that students with ADHD are less adept at resolving conflict, and it is

possible that some of the disagreement we observed between the students was due more to their individual ability level than to the design technique.

Technique

During the Big Paper session, there was an initial reluctance in some of the small groups to begin to draw on the big paper. Millen et al. (2011) describe comparable results when asking children on the autism spectrum to engage in unstructured tasks. During our Mixing Ideas session, we observed a similar problem with the unclear task to mix disparate ideas together. However, during both sessions, with adult design partners present to facilitate and contribute, it was possible to direct the activities without having the children exhibit too much frustration. The Storyboarding session had several challenges as well. Researchers accidentally placed paneled outline of the game on the wall in the wrong order, greatly confusing some of the children and the researchers. Additionally, the children wanted to continue to generate design ideas as they had during the previous two sessions rather than focus on narrowing their ideas as researchers intended during the session.

The Bags of Stuff session was by far the favorite activity reported by the children. When asked their favorite session at the end of the design cycle, six out of nine present children stated they liked the Bags of Stuff session the most. This session was slightly different from the other sessions in that we asked the design team to focus on a different design problem than their game. We chose to include this session to give the participants a break from the design problem, to allow our programmer time to make changes to the game, and to generate ideas for the next semester's work in another classroom, as well as to try the Bags of Stuff techniques with the current class. However, the children again felt as though they had less direction than they needed

when initially beginning to build low-tech prototypes. The small groups ultimately successfully created prototypes. During this session, as with the Big Paper and Mixing Ideas sessions, the direction of experienced adult design partners was invaluable to keeping the child partners on-task, although enthusiasm and enjoyment were not lacking.

The least favorite sessions reported by the children 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. During this session, a newly purchased pack of batteries failed, and the camera given to the child partners ceased to work. As backups, researchers gave the children their personal cell phones and two other cameras (present for recording the session as a whole). However, we believe that due to unfamiliarity with researchers' phones and difficulty operating them, the child partners reported dissatisfaction from the session. In analyzing the footage captured from the children, there are only 15 videos ranging from a few seconds to three minutes for the entire hour's session.

Session Structure

We found a number of limitations to the structure of our sessions. These limitations pertain to the length of time of each session, the level of personal engagement with the researchers, ease of distraction, the design materials available, number of researchers available, and the physical space of the classroom. Leveraging these session structure findings to make

Cooperative Inquiry techniques better applicable with classrooms of children with special needs will be addressed in the discussion section.

In regards to length of session, each session lasted one hour, and we found that this was not enough time to address all of the segments of the design session including the introduction to the design problem of the day, the design activity itself, and then 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 to re-engage them.

As the number of visits to the participating school increased, we found the children asking more questions and engaging with researchers more often. They asked where we were from, about our 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 aspects of the game design. There was no designated time in the design process to allow for this sort of discussion.

We found that it was easy for the children to get off task in all the sessions during the presentation time when each small group took turns sharing their design with the rest of the class or when engaging each other during the introduction of the design problem of the day. Both of these were whole-group activities. Generally, these discussions would begin with the designated speaker and one other child, but would quickly engage the rest of the children and disrupt the activity. The children in general had difficulty remaining focused for all of the design activities. 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

child partners could become off-task in general as an aside to a researcher; that this was not an issue unique to our design sessions.

The children asked to use design materials outside of what was presented to them. For example, they wanted to use personal supplies of scissors and markers during some sessions. Additionally, the children used some design materials in unexpected ways; colored pencils became a tail for a robot, for example. 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.

While in an ideal setting, we would have assigned one researcher to stay with each small group of children, on occasion it was necessary for researchers to leave their initial group and move around the room to other groups due to the limited number of researchers present. This lead to a lack of true partnership between children and adults during some sessions, as an adult design partner was not present with each group to contribute to the design idea and elaborate with the child design partners throughout the entire design.

As all of the sessions took place within a classroom, the physical space was somewhat limited, as the classroom was crowded with desks and other materials. During sessions where we needed floor space, as in Big Paper, Mixing Ideas, or Bags of Stuff, that there was less space than would be desirable, and starting the session 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.

Discussion

Based on our experiences at the participating school, we make the following recommendations for designing technology with children with learning disabilities, ADHD, and mild autism spectrum disorders 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. We 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 typically developing children in the lab, this informal time is built into the session structure at the beginning of each design session, and aids in establishing solid relationships between child and adult team members. For all child design partners, and especially for those on the autistic spectrum, we believe that this additional informal time might serve to allow adults to get to know the children better (e.g. Benton, et al., 2011; Moffatt et al., 2004), as well as allow the children to become more comfortable with the researchers. We acknowledge that the amount of time recommended may make conducting design session during school hours difficult, and that perhaps after school design session may have to be conducted.

High Adult-to-Child Ratio

We 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 a 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 capture fully all ideas from children who may not be adept at verbal communication, the consistent adult researcher can assist in presenting ideas to the larger group. The literature surrounding design work with children with special needs also recommends involving higher ratios of adults (Benton et al., 2011; Hornof, 2008).

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. This finding is echoed by the classroom teachers, **"**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 typically developing children 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, we feel that students with learning disabilities might be more fully supported with their difficulty recalling information (Brigham, Scruggs, & Mastropieri, 2011).

High Engagement

In the laboratory setting, the design team rotates through projects rapidly, often working on many projects during the course of a semester. At the participating school, the children were heavily involved in the development on a single product where they were completely responsible for all of the design decisions. The students at the school were engaged, showed a desire to participate in all aspects of the design process, and were able to see the results of their design

work relatively quickly. Preparation for this more immersive involvement can improve the experience of the student partners. For example, adult design partners can place more responsibility for the outcome of the session on the child design partners by allowing them to cluster stickies by theme or summarize the design outcomes, which child partners in the laboratory setting do not generally do. In the future, allowing the child design partners to participate in programming activities could enhance their experience and foster a fuller partnership in the design of the system.

Limitations

We recognize that there are limitations in this project. Ten children may seem to be a small population, however, ten 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, we 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.

The recommendations identified by this project for changes to Cooperative Inquiry techniques with a special needs population should be implemented with diverse populations to learn their applicability to various special needs populations. Conducting a similar project with other classrooms can inform the above recommendations, as well as further establish the broad applicability of Cooperative Inquiry to populations with differing learning needs, along with uncovering any further modifications that might be needed. Additionally, a wide age range should be included in future work by conducting a mixed age and gender group with child design partners having special learning, developmental, and emotional needs. Conducting a similar

project with children with more severe disabilities could uncover what further modifications or other approaches are necessary for a successful design partnership.

Future Work

We plan to continue this work with a second classroom at the same private school to test the above modifications. The second classroom is also comprised of only boys ages 11 and 12. The recommendations for changes to the techniques uncovered by the current project will be applied to the project in the second classroom, and a comparative analysis between the experiences for the students will be conducted.

Additionally, future work should include design teams comprised of children with learning and developmental disabilities but in the laboratory setting. This will allow researchers to isolate whether the results observed in this project are due to the setting of the project or due to the differences between typically developing children and children with learning or developmental challenges. Finally, the functioning of a design team with equal proportions of children with learning and developmental differences and children who are typically developing should be investigated.

Implications

This project has enabled researchers to establish that the design method Cooperative Inquiry can be used when working with a population of children with special learning needs, specifically with learning disabilities, ADHD, and autism. In the past, this method has mainly been used with typically developing children and in a laboratory setting. This project broadens the applicability of Cooperative Inquiry to classrooms and to populations of children with differing abilities.

Additionally, when considering how to design technologies that are best suited for use by children with special learning needs, we believe that it is best practice to involve the end-user group in the design process. By establishing that Cooperative Inquiry can be used with children with special learning needs, researchers can use the method to design technologies that are more effective for this group of children in the future.

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