SIDES: A Cooperative Tabletop Computer Game for Social Skills Development

Anne Marie Piper, Eileen O'Brien
Stanford University, School of Education
485 Lasuen Mall
Stanford, CA 94305
{ampiper, emobrien}@stanfordalumni.org

Meredith Ringel Morris, Terry Winograd
Stanford University, Department of Computer Science
353 Serra Mall
Stanford, CA 94305
{merrie, winograd}@cs.stanford.edu

ABSTRACT
This paper presents a design case study of SIDES: Shared Interfaces to Develop Effective Social Skills. SIDES is a tool designed to help adolescents with Asperger's Syndrome practice effective group work skills using a four-player cooperative computer game that runs on tabletop technology. We present the design process and evaluation of SIDES conducted over six months with a middle school social group therapy class. Our findings indicate that cooperative tabletop computer games are a motivating and supportive tool for facilitating effective group work among our target population and reveal several design lessons to inform the development of similar systems.

Categories and Subject Descriptors
H.5.3 [**Information Interfaces and Presentation (e.g., HCI)**]: Group and Organization Interfaces – *computer-supported cooperative work.*

General Terms
Design, Human Factors.

Keywords
Tabletop groupware, CSCW, computer games, Asperger's Syndrome, social skills development.

1. INTRODUCTION
Interactive table technologies are a new medium through which adolescents who have difficultly learning to work effectively in group situations can practice group work skills in a supportive and motivating way. Tabletop technology encourages group interaction around one interface in a way that other computer workstations and video gaming systems do not. Computationally-enhanced tables allow face-to-face interaction and multiple simultaneous inputs from a group of users. Applications designed to run on tabletop technology have the ability to require user-specific actions and cooperative actions [17]. We implemented SIDES, a four-player cooperative computer game for social group therapy, on the DiamondTouch table [5], an interactive tabletop surface that can receive multiple simultaneous inputs and uniquely distinguish between each user's touch. This functionality allows application designers to restrict or require input from certain users during the tabletop activity. SIDES leverages the affordances of tabletop technology to encourage cooperative decision making and equitable participation by group members, aspects of group work that are particularly difficult for adolescents with Asperger's Syndrome to learn and for their social skills therapists to moderate in traditional group work situations.

Asperger's Syndrome (AS) is a Pervasive Developmental Disorder and is considered an Autism Spectrum Disorder. Statistical data on the prevalence of AS is unclear, as many cases go undiagnosed or are misdiagnosed. It is estimated that AS occurs in 3.6 to 7.1 of 1000 children [6]. While children and adolescents with AS often do not have significant delays in cognitive and language development, these individuals have difficulty understanding accepted social conventions, reading facial expressions, interpreting body language, and understanding social protocols. These social deficits can lead to challenges in learning effective group work skills, including negotiation, perspective taking, active listening, and use of pragmatic language.

Adolescents with AS often describe the computer as a comfortable and motivating medium. Through our approach we leverage the comfort of working with a computer to help these individuals practice effective group work skills. Our evaluation of SIDES reveals benefits inherent in the use of tabletop technology as a therapy tool for this audience and discusses the tradeoffs of supporting this type of group activity with computer- versus human-enforced rules. Through our analysis, we found that the affordances of tabletop technology -- specifically the ability of tables to facilitate face-to-face interaction, allow simultaneous user input while controlling individual user actions, and encourage cooperative decision making -- were critical in successfully supporting cooperative work with our target user group and have valuable implications for the broader CSCW community.

2. BACKGROUND
The majority of computer programs for social skills development for our target audience are designed for one user working directly with the application and lack the face-to-face interaction found in authentic social situations [1][23]. Social skills therapy groups help adolescents with AS learn strategies to navigate social situations. Social skills therapists who lead these groups often use card and board games to help adolescents practice appropriate

social interaction techniques with peers. These traditional games, however, may not sustain interest or motivate students enough to overcome challenges in social interaction. Traditional board games can be inflexible and may be difficult to modify to support current classroom topics and learning goals.

On the other hand, tabletop technology is a unique platform for multi-player gaming that combines the benefits of computer games with the affordance of face-to-face interaction. Tabletop computer games have recently been explored for general audiences [12], [13], but have yet to be designed for a special needs population who would especially benefit from social computer games.

3. RELATED WORK

There are currently a number of single-user computer programs to help with social skills development. These existing applications typically focus on rote memorization of facial expressions and emotions (e.g., Mind Reading: The Interactive Guide to Emotions [1] and Gaining Face [23]). Memorization of social cues may be helpful to some adolescents, but this isolated activity lacks a supportive and authentic context for application of these skills. Teaching appropriate social protocols with virtual reality has also been explored as in [3], [11]. Despite advances in facial imaging, it is difficult for computers to completely replicate the nuances of human social behavior. Though social cue memorization and virtual reality applications are valuable, neither of these approaches provides a fully supportive and authentic means of practicing effective group work skills.

The goal of our application is not to teach skills explicitly, but rather to provide a motivating and supportive experience through which adolescents may practice social and group work skills discussed in group therapy sessions. The pedagogical design of SIDES stems from Vygotsky's theory that learning is a social process and has its roots in social interaction [24]. Collaborative activities and cooperative games have been shown to specifically benefit individuals with AS [11]. Video games have been used as a method of facilitating therapy and rehabilitation for certain special needs audiences [8], but not as the means of a cooperative activity for this audience. SIDES leverages these educational theories and the prior work described above to provide an authentic and engaging activity to supplement current therapy techniques for teaching social and group work skills.

The term "single display groupware" (SDG) refers to systems that support co-located, computer-supported cooperative activity around a single, shared display [22]. Interactive tables, such as the DiamondTouch table [5] are a form of SDG that promote face-to-face interaction (rather than the shoulder-to-shoulder interaction style promoted by vertical, wall-mounted displays). Studies comparing face-to-face and shoulder-to-shoulder work styles [18] have found that around-the-table style interaction promotes more communication and participation from group members, which can be especially beneficial for individuals with AS. Individualized control over input devices has been linked to increased performance and achievement in computer games with adolescent pairs [9]. Tabletop technology has the functionality to provide each group member with individualized control over the interface, which may be particularly useful for adolescents with AS who describe the control they have over computers as comforting. Researchers have explored the benefits of tabletop displays for educational activities [16], but have not explored how tabletop interfaces might be designed to maximize educational benefits for populations with special needs.

4. DESIGN PROCESS

We conducted observations, interviews, and paper and digital prototype tests over a period of six months with middle school students (11-14 years old) and therapists from a social skills therapy group. Twelve students and their school-designated social skills therapist were involved in this study. While the majority of students in our study have a primary diagnosis of AS, other students from this class who participated in the study have social skills challenges stemming from other disorders, including diagnoses of High-Functioning Autism, Attention Deficit Hyperactivity Disorder (ADHD), Apraxia, and Klinefelter's Syndrome. Our methodology for understanding the needs and learning goals of this population included participant observation as well as group and individual interviews. We employed a participatory design approach [19], as this inclusive design process is described as essential and critical in creating a satisfactory solution when designing for special needs populations [7]. Our research team involved students and adults with AS, social skills therapists, and parents of children with AS in all aspects of design and evaluation.

4.1 Design Goals

Our goal was to develop a cooperative, multi-player tabletop computer game that encourages meaningful application of group work skills such as negotiation, turn-taking, active listening, and perspective-taking for students in social group therapy. We intentionally designed SIDES to leverage the cognitive strengths and interests of individuals with AS. In our interviews with children and adults with AS, we heard many individuals describe an interest in visual games such as puzzles; as a result, we created a puzzle-style game. AS occurs in only one female for every four males [6], so we chose a game theme of frogs and insects in order to appeal to our predominately male, adolescent audience. For adolescents with AS, the challenge in playing any game is learning to work cooperatively and play fairly with each other; our goal with SIDES was to design a game that facilitates cooperative game play in a meaningful way.

Figure 1: Our design process (left to right) included brainstorming sessions with experts, interaction storyboards, paper prototype tests, interface mockups, and DiamondTouch implementation and evaluation.

4.2 Field Studies and Observations

As participant-observers of a middle school social skills therapy class, we sat with students and participated in group discussion on topics such as listening, turn-taking, and leadership. We attended seven sessions, each lasting approximately one hour, to investigate current approaches to teaching social skills as well as student interests in and out of the classroom. We conducted six interviews with middle school social skills therapists and speech pathologists to understand current teaching methods and classroom techniques and to identify potential solutions for teaching group work skills. Working with this user group was challenging, as illustrated by a comment from the social skills therapist who leads this social therapy group:

> "Some of my kids go into mainstream classes and they just can't work with other people. We have to find the right mainstream kids who will have the patience and tolerance to deal with our kids' behaviors. Then some of our kids just flat out refuse to work in groups because they don't want to give up their power and control. Control for these kids is not something they have a lot of so they try to control their environment."

When we were able to conduct interviews with students from this class, we faced challenges in building rapport and making students feel comfortable during the interview. One student, for example, "shut down" during her interview. She would not make eye contact and only provided one-word answers to open-ended discussion prompts. Instead of one-on-one interviews, we adjusted our method of data collection and found that group interviews with four or five students from the class were more productive.

Interviews with students from this class revealed discontent with current group therapy activities such as discussing emotions and reporting on weekend activities. We found that "game day" (therapy sessions where students play board games) was one of the few interview topics that elicited positive and excited responses from students. One seventh grade girl from this social group therapy class pointed out that the challenge in designing a motivating and exciting game is to avoid creating a game that appears overtly educational. This student is an avid gamer and is currently designing her own computer game. When asked how she would design a game to teach the social skills topics addressed in group therapy, she replied, "I don't know. I don't really like those types of games. I don't *do* educational games." She then explained that "entertainment games are just when you're doing them for fun" and educational games "start teaching you stuff and they get away from all the entertainment and fun." We realized that the challenge in designing a compelling cooperative game for this audience would be to create an engaging experience that does not directly focus on traditional content from social skills therapy sessions.

Games are a prominent theme that emerged from our observations and interviews. Students in this class frequently play online games and video games at home. We found that board games are often used as a tool during therapy sessions. Though classroom game time is particularly beneficial for this audience, the activity must be closely monitored to prevent verbal and physical altercations. The students' social skills therapist commented, "With these kids we have to be on alert when they are playing board games in class. We walk over at the first sound of voices raised. Other kids would be fine and could work out a disagreement, but with our kids we have to monitor behavior very closely and know when it's time to intervene." We realized that regardless of our game design, an adult may have to monitor game play for behavioral purposes.

4.3 Game Rules

We created a highly visual, four-player puzzle game and designed the rules to increase collaboration and decrease competition. At the beginning of a round, each player receives nine square tiles with arrows (three copies each of three arrow types) (Figure 2). Unique arrow types (e.g., pointing left, pointing right, around-the-corner, etc.) are distributed among participants so that no participant has all 12 arrow types in their "hand." Students are asked to work together to build a path with their pieces to allow a "frog" to travel from the start lily pad to the finish lily pad. There is a limited supply of each arrow type, thus encouraging students to cooperatively build an optimal path to win the most points. To gain points, the path must intersect with insect game pieces on the board. The insects are worth various point values (e.g., each dragonfly is worth 20 points). The group of students must agree on one path that collects the most points with their given amount of resources. Once all players agree with the solution, the frog will travel along the path and collect points by eating all the insects it encounters.

4.4 Paper Prototype

We tested a paper prototype of SIDES to finalize the rules, check for game balance, and determine whether this initial prototype showed enough promise to be turned into a digital game. The paper version of SIDES is ideally suited for four players, but more people can play with minor adjustment. We tested the prototype with two five-student groups from the social skills therapy class. After playing multiple rounds, we held a group interview and brainstorming session about the gaming experience. The students were positive about the game design and flow of game play. Students gave positive feedback on the frog and insect theme and offered numerous thematic suggestions. After observing both groups play the prototype, the students' therapist commented, "I was impressed with how they all shared the responsibility and actually played collaboratively rather than one person dominating… even those who are normally the least active in the

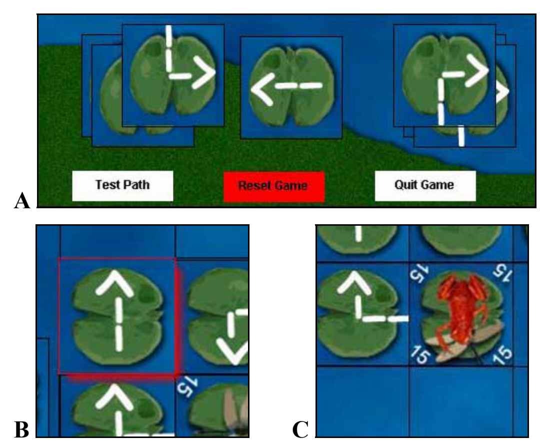

Figure 2: Interface components: A) Each player has a control panel with voting buttons located along the border of the table nearest each user's seat. B) Arrow pieces highlight with the player's color when touched. C) The frog "hops" along the path and eats insects to win points.

groups were active and engaged the entire time." The paper version was successful in that it provided proof of concept for a cooperative game design. However, there are still significant advantages of a computer version for these adolescents. A computer game can enforce rules without the therapist having to police game play, thus freeing up his/her time to attend to higher-level group work issues. Also, adolescents with AS typically find comfort in controlled and structured interactions with a computer, thus making a computer version even more promising.

4.5 DiamondTouch Implementation

After successful testing with the paper prototype, we implemented a computer version of the game in Java for the DiamondTouch table [5], a multi-user touch sensitive tabletop with a top-projected display. We wrote our application using the DiamondSpin tabletop user interface toolkit [21]. As with the paper version, players seated around the table receive game pieces to place on the board and create an optimal path from the start to finish. Game pieces with different types of arrows (as in Figure 2) are divided among players and are initially located in piles directly in front of each of the four users. We chose this distributed initial configuration of game pieces based on findings from [20], where the center area of the table is perceived as a group space and areas directly in front of each person are considered spaces for personal items. We did not incorporate a timer or impose any time limits on the game to prevent students from feeling rushed and forgoing collaboration just to reach a solution. The computer version gives each player a control panel in the region of the interface closest to his or her chair (see Figure 2A). In each player's control panel are round and point indicators as well as *voting buttons* to test the path, reset, or quit the game. The voting buttons force the group to "vote" unanimously in order to change the state of the game. For instance, players must vote unanimously to test their path once a solution is reached by each activating their own "Test Path" button. This feature was implemented to ensure that no one player had more control over the state of the game than another player, and to encourage social interaction by necessitating communication and coordination with other members of the group. This first version of the computer game did not enforce rules such as turn taking or piece ownership. This design decision was made so that the game remained more open-ended and we could investigate the minimal amount of structure necessary for encouraging effective group work.

5. EVALUATION – SESSION 1

The primary research questions that guided Session 1 include:

- Are tabletop computer games an appropriate and feasible tool for facilitating social skills development for this audience?
- Do any sensory or motor issues specific to this audience affect interaction with tabletop technology?

5.1 Method

Participants. We tested this initial design with five students from the same social cognitive therapy class we observed and with whom we tested the paper prototype (Figure 3). These students were all male (mean age of 12.6 years, stdev=0.89) and in the same social skills therapy class. This group consisted of three adolescent boys clinically diagnosed with AS, one with Apraxia, and one with Klinefelter's Syndrome.

Environment. The DiamondTouch table is difficult to transport to a testing site, so students came to our university lab to play the digital version of SIDES. Several of the students' parents and their social skills therapist from school came to the lab at our university to oversee the testing session. Several parents requested that they be present in order for their son to participate, so they quietly observed the session from the other side of the lab. In more authentic, non-testing situations, we expect that parents would be present while their children were using SIDES, so the presence of parents during out testing session should not confound our results.

Procedure. In this version of SIDES, the computer did not enforce rules. The therapist facilitated game play, monitored student behavior, and led a group discussion after play ended. Students played for two half-hour blocks of time. Following each half-hour play session, students discussed their experience with the therapist. The game is ideally suited for four players, so students rotated in and out after each round of play (where a round entails the successful completion of a path connecting the start and finish lily pads). This group played a total of six rounds, so each student averaged four or five rounds of play. Before beginning, the students were given a brief tutorial on how to use the DiamondTouch table and then instructed to work together to come up with one solution while playing SIDES. Two researchers observed the testing sessions and took detailed notes. The game play and discussion were videotaped for later analysis. All interactions with the interface were logged by the computer. Students individually completed a questionnaire after playing SIDES but before the group discussion.

5.2 Findings

We found that students remained engaged in the activity the entire time and were excited by the novelty of the technology. However, the students' excitement around playing a computer game on new technology in a new environment provided additional behavioral challenges. The students' therapist commented, "Even though their behavior was very positive, they were still talking over each other and not taking turns like we discuss in group therapy… they were really enthusiastic and had difficulty navigating back-and-forth conversation."

Some students exhibited a high level of control over their behavior and made positive contributions to the group without dominating

Figure 3: Four students playing SIDES during Play Testing Session 1.

the activity. Drew[1], a seventh grader with AS, suggested several strategic moves to the group but was repeatedly ignored. Later he commented on the group's final solution, "It's not exactly like my planned route, but it's close enough." Drew's comment illustrates *perspective taking*, realizing that other people have different yet valid ideas, a topic that is frequently discussed in group therapy. Drew's mother observed the testing session from the other side of the lab. After the session she explained,

> "I've actually found it rather interesting watching my son because he tends to be decisive about things and be more of a leader, but he's not forcing his will on anyone else here at all. He's listening and seemingly much more socially conscious than I think of him in terms of trying to be involved, but not trying to take over or get angry. So I'm actually quite pleased to see that."

In contrast, some non-cooperative behaviors indicate that additional structure could have helped other adolescents control their impulse to dominate the activity. Several rounds of play were chaotic with kids pushing each others' hands off the interface and yelling loudly. One outspoken student often took control of the game, reaching across the table to move other players' pieces without asking and telling others which piece to play next without eliciting input. This student's father observed the testing session and commented,

> "With [my son], tact and making other people feel good about what they're doing doesn't even enter the equation… he'll try to get the ideal result of whatever problem is in front of him and how that impacts other people doesn't even occur to him. That's what he needs to learn more of. Games like this give him more practice."

In the debrief immediately following the gaming session, the students gave an overwhelming response regarding the need for order while playing. One commented, "There always has to be a leader; otherwise it will be wild and nobody will get anything from it." In response to this comment, Brad, a seventh grade student, stated, "We're supposed to work together. We're supposed to be equals." Brad was the quietest participant during the testing session and quickly became agitated and covered his ears when his peers spoke loudly at each other. During an individual follow-up conversation with Brad, he explained, "Last time it was chaos." He looked at the ground and paced back and forth, "yeah, it was really chaotic until I got to be the leader." By "leader" Brad is referring to a point in the session where the therapist closely monitored the students and gave each a chance to make decisions for the group.

In this first round of testing, we wanted to assess the appropriateness of tabletop technology for this audience. Our primary concern was whether these adolescents could learn sufficient control over the interface given the tactile input required by tabletop surfaces. Participants answered "How hard was it to move the pieces around on the table?" with a mean of 2.2 (stdev=0.45) on a five point Likert scale (1 = "not at all difficult" and 5 = "extremely difficult"). Based on the self-reported response by students and observations by the two researchers running the session, we conclude that participants found the mechanics of using the touch-sensitive tabletop technology manageable.

Overall, the students found SIDES to be a highly motivating yet challenging experience. After playing, one eighth grade student remarked, "Are we going to play again? I want to play it in the classroom." According to the students' therapist, this excitement carried over into the classroom for several days after the session and caused group discussions about the gaming experience, allowing him to tie the experience back into current classroom social skills topics. Session 1 demonstrated the promise of tabletop computer games as a tool for helping our target user group practice effective group work skills, as these adolescents were highly engaged with each other during the game and motivated by performance.

6. DESIGN ITERATION

Play Testing Session 1 revealed that SIDES was motivating for these adolescents and is a promising tool for supporting effective group work among this user population. Session 1 also suggested that explicit game rules such as turn taking and piece ownership might help reduce controlling behaviors of some students and encourage other less engaged members to be more involved in the activity. We revised the game to include computer-enforced turn taking and restricted access to game pieces, as per our observations and feedback from the students' therapist. After Session 1, the therapist suggested, "Whoever's turn it is should be the only one who can manipulate the pieces. You can see that the kids can't keep their hands off. They will reach over and if one kid is too slow or taking in more information, they might not be able to wait and will break the rules by stealing another person's piece." The computer provides hard, fast, and consistent rules in a

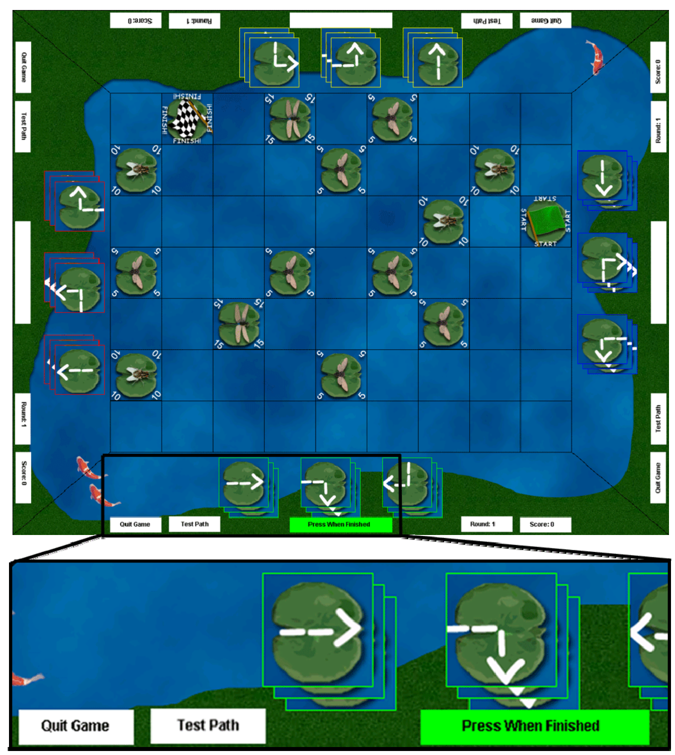

Figure 4: A "turn taking" indicator is located in front of each player next to their voting buttons. Only one turn taking button highlights at a time to indicate which player's turn it is. In this image, the green player's button is highlighted (located on the interface directly in front of this player) and all other turn taking indicators are white and inactive.

[1] All names have been changed to preserve anonymity. Photos are used by permission.

way that the therapist as a human facilitator cannot. The rule enforcement was enabled by the DiamondTouch table's ability to distinguish between four distinct users and to associate a user identity with each touch input. Thus, the "piece ownership" rule only allowed players to move the pieces that were given to them at the beginning of the game; attempts to move other users' pieces were ignored by the system.

We also redesigned the control panel in front of each player to include a *turn taking button* (Figure 4). Each player's turn taking button indicates whether or not it is that player's turn. A player may make as many moves with their own pieces during their turn as they like. The player whose turn it is has control over when they end their turn by pressing their turn taking button. We implemented a "give" protocol as described by [9] and [10] to prevent one student from "stealing" control from another player. Our intent behind implementing this turn-taking mechanism was to give players a feeling of ownership over the activity while still encouraging negotiation between players. Our rational for not implementing a game timer was to prevent players from feeling rushed or pressured to think quickly and make a move, as this may lead to anxiety, disruptive behavior, and discourage cooperative discourse. Play proceeds in a clockwise fashion as each player moves a piece(s) and relinquishes his turn. Players are allowed to "pass" if they do not want to play any pieces.

For Session 2, we decided to test the controlled access (players can only move their own pieces) and turn-taking features in combination, as this requires players to communicate more and to become coordinated in their attempts to create a solution. In our second evaluation, we examined how the adolescents from Session 1 and others from their class practice effective group work skills when playing a cooperative computer game under three conditions: (1) without enforced piece ownership and turn taking, (2) with piece ownership and turn taking enforced by a human facilitator, and (3) with computer-enforced piece ownership and turn taking.

7. EVALUATION – SESSION 2

Session 2 focused on how these adolescents respond to computer- versus human-enforced rules and how elements of our design impact performance. The following questions guided this testing session:

- How do students respond to computer-enforced rules versus rules provided by a human facilitator?
- Do any aspects of the current design encourage or discourage effective group work with this audience?
- What is the role of a social skills therapist during a tabletop computer activity with this special-needs population?

7.1 Method

Participants. To address these questions, we tested three variants of SIDES with two groups of four students, all from the same social therapy class. Group 1 consisted of four male students who participated in Session 1. The mean age of this group is 12.5 (stdev=0.58). The clinical diagnoses of individuals within Group 1 included two adolescent boys with AS, one with Apraxia, and one with Klinefelter's Syndrome. Group 2 consisted of four students, none of whom had played the digital version of SIDES yet, but three of whom had played the paper version in class. The mean age of Group 2 is 12.8 (stdev=1.5) and consisted of three male students and one female. In this group, two students were clinically diagnosed with AS, one with AS and ADHD, and one with High-Functioning Autism.

It is important to note that students in Group 1 had prior experience working with each other while playing the earlier version of SIDES during Session 1. In Session 1, these students experienced the "chaos" of playing without rules (i.e., no enforced piece ownership or turn taking). This experience gave them a benchmark to which they could compare their experience in Session 2. Group 2 had limited exposure to the game and minimal experience working with their set group of peers. For this reason, and due to the limited scope of our data set, we do not directly compare the two groups in Session 2. Instead, we treat the two groups as separate cases and seek to understand design implications based on the varying group dynamics and reactions to the activity.

Environment. The environment for this testing session, our university lab, was identical to that of Session 1.

Procedure. The two groups were presented with conditions as follows: Group 1: N, H, C, N and Group 2: N, C, H, N, where N = no rules, H = human-enforced rules, and C = computer-enforced rules. Each condition was presented as one round of play, where a round consisted of the group's successful construction of a complete path. In the N condition, students were presented with the basic version (similar to the version in Session 1, but with slight modifications to improve system performance) where no rules were enforced by the system and the therapist had limited involvement. The H condition again presented students with the basic version where rules were not enforced by the system, but under this condition, the therapist facilitated turn taking and enforced the "controlled access" of game pieces, only allowing students to move or play their own game pieces. In the C condition, turn taking and controlled access were enforced by the computer and the therapist had limited involvement in the activity, only providing occasional comments related to the group's strategy. Since Group 2 did not have prior experience with the computer version of SIDES, this group played the basic version without rules for approximately ten minutes to become familiar with the game and their teammates before beginning the conditions above. The same researchers who observed Session 1 also observed and took notes during Session 2. All game play and discussion was again videotaped for later analysis. Interactions with the interface were logged by the computer. After the testing session, students individually completed a questionnaire to compare the above conditions and then participated in a follow-up group interview.

Conversation Analysis. We evaluate each group's performance individually and compare the reactions to the three conditions by each group in several ways. While we present self-report questionnaire data and feedback from follow-up student and adult interviews, a critical part of our evaluation involves conversation

Table 1: Categories for Conversation Analysis

Positive	Aggressive	Non-Responsive
• Verbal agreement • Agreement by making suggested play • Encouragement	• Verbal command • Pushing • Loud outburst, screaming • Teasing	• Ignore or dismiss idea without discussion • Ignore/disregard therapist

analysis over multiple rounds of play. The challenge these individuals face is not a lack of interaction so much as a lack of effectiveness in interactions [2], thus the effectiveness of verbal and non-verbal exchanges is an important indicator of cooperation by these adolescents. Our research team reviewed videos of both groups for Session 2 and independently coded verbal and non-verbal exchanges according to Table 1. We developed this coding scheme by consulting with psychiatrists and social skills therapists specializing in adolescents with AS, referencing the Diagnostic and Statistical Manual of Mental Disorders (DSM IV), and using our observations of play testing sessions to identify prominent themes. Interrater reliability between two researchers who categorized conversational exchanges was above 85% (calculated with the Kappa statistic [4]).

7.2 Group 1 Findings

According to our observations and student discourse, students in Group 1 exhibited an increase in positive language use as well as a decrease in the amount of aggressive behaviors over multiple rounds (Figure 5).

Based on conversational exchanges between group members, Group 1 as a whole performed best in the computer-enforced rules condition. Group 1 also demonstrated an improvement in conversation over the course of the trial and sustained this improvement in the final round without rules, the condition described as most difficult by students in Group 1. These students quickly adapted to the computer-enforced rules condition, becoming highly coordinated by skipping turns to get to a player who owned the piece necessary for the next move. Three out of four students in Group 1 rated the game as *easiest to play* when rules were enforced by the computer. Three out of four students in Group 1 also reported that they were *most relaxed* when rules were enforced by the computer. No students in Group 1 rated the computer-enforced rules condition as the *most difficult version to play* or as the condition they thought was *most chaotic* or *most frustrating*. Three out of four students in Group 1 said they *worked together best* during the computer-enforced rules condition and all four students reported that they *worked together worst* when there were no rules (condition N).

For this group, the computer-enforced rules condition encouraged cooperative group work because the structure helped prevent one dominant player from taking control of the game, as seen in the rounds without rules and in Session 1. With computer-enforced rules, each player had a clearly visible chance to "own" game play and make a contribution to the group's final product, one cohesive path. We suspect that for this group, the regimented group work experience was helpful in preparing students to work together in the final, unstructured round. During the debrief after Session 2, the therapist said to his students in Group 1, "You guys didn't even notice that in the last round you could touch each others' pieces and play in any order. You didn't reach across and take people's pieces like before. You kept working together."

7.3 Group 2 Findings

In contrast to Group 1, all students in Group 2 stated that the game was *easiest to play* and that they *worked together best* when there were no rules. Three of the four students also indicated that they were *most relaxed* when there were no rules. The conversation analysis of Group 2 echoes the student questionnaire data. Group 2 exhibited more positive conversational exchanges and fewer aggressive behaviors in the no rules conditions (Figure 6).

Students in Group 2 sustained the same level of positive conversational exchanges and only slightly increased in aggressive behaviors over the four rounds. Group 2 indicated that the no rules condition was easiest and demonstrated conversation and behaviors that support their questionnaire responses. This group, however, did not indicate a majority opinion for the questions asking which version was *most chaotic* and *most frustrating*, but split their responses between the two conditions with rules. Responses to the condition under which the group *worked together worst* were also divided between the human- and computer-enforced rules conditions.

The challenge for students in Group 2 to work effectively in the structured conditions is partially due to the inflexibility of one player in this group, Brandon. Brandon (age 11) consistently expressed skepticism about the team's solution and delayed the game by refusing to give up his turn even if he did not have any pieces to play. After observing Session 2, the therapist said, "I wish I could get the rest of my students to play this because it really gives me an idea of what's hard for each individual. Like with Brandon, I had no idea he had such issues trusting other students until I saw him unwilling to give up his turn when the computer was enforcing turn taking." For a group dynamic similar to that of Group 2, a "give" protocol in a turn-taking exercise can be problematic and detrimental to the group activity.

8. DISCUSSION

SIDES provided an engaging experience for students who typically find group work extremely challenging and a source of anxiety. The students who played SIDES made a concerted effort

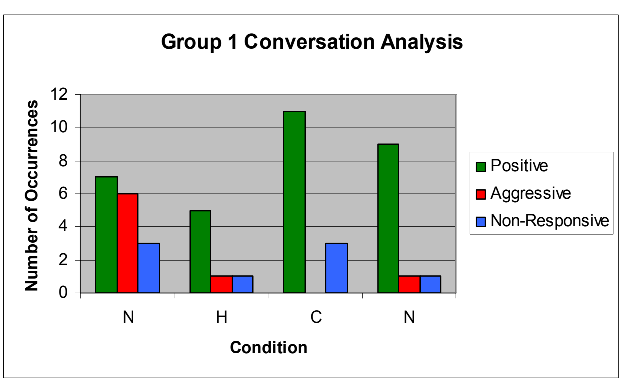

Figure 5: Number of occurrences of positive, aggressive, and non-responsive behaviors for Group 1.

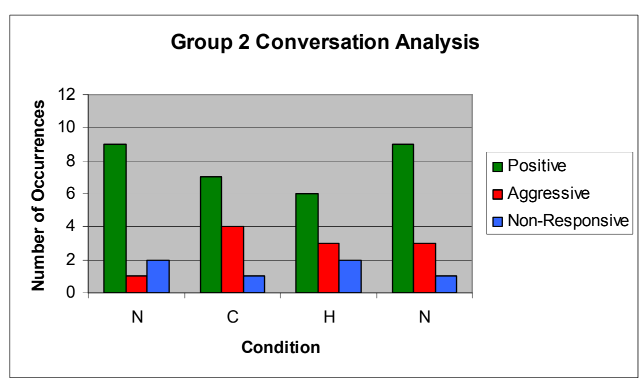

Figure 6: Number of occurrences of positive, aggressive, and non-responsive behaviors for Group 2.

to work with each other and remained engaged in the activity the entire time. Unlike traditional evaluations that do not target special needs populations, the learning that occurred during our testing sessions is impressive for these adolescents, as they quickly disengage from group activities when unmotivated by or uninterested in a task. Whether this behavior was a result of increased familiarity with the activity or their peer group, each group's demonstrated interest in the activity and attempt to cooperatively devise one solution are successful outcomes for this user population and should not be underestimated. Even minimal strides in social skills development may not be visible until after months, even years, of exposure to therapy techniques. Our findings focus on initial exploration of tabletop technology as a tool for supporting effective group work with this audience and are not intended to capture sustained behavioral or long-term changes in these students, though this would be useful for future studies to address.

8.1 Design Lessons

We now present several design lessons from our development and evaluation of SIDES to help inform the design of future cooperative tabletop applications geared towards similar audiences.

8.1.1 Tabletop Technology as a Design Platform

We saw many benefits inherent in our use of tabletop technology as the platform for an educational game for this audience. Interactive tabletop technology inherently supports social interaction and provides a shared experience for learners and educators, both of which are central to one's learning process [24]. In an educational setting, it is useful that the DiamondTouch table is able to distinguish between users and provide feedback on an individual basis [16]. The specific hardware configuration of the table that allows user identification, however, also presents drawbacks for our user population and children in general. The DiamondTouch table requires users to remain capacitively coupled to the table (i.e., remain seated) to interact with the interface. This means that not only do students have to control their behavior and stay in their seat, but that serendipitous play by an observing student, therapist, or parent is not allowed. Furthermore, one of the shorter students had difficulty reaching across the table (which measures 107 cm diagonally) while remaining seated and thus had trouble accessing any game pieces that were on the opposite side of the table. The ceiling-mounted projector that displays information on the interactive table surface also presents problems in that students must be extremely careful not to bump the table and misalign the projected image. The current state of tabletop technology, specifically the DiamondTouch, has promise as a medium for social computing applications for our target audience. It will be challenging, however, for tabletop computing experiences to impact larger special needs populations until more robust, elegant, and affordable tabletop systems are developed.

8.1.2 Sensory and Motor Issues

The direct-touch input system of tabletop technology benefits our audience because it allows individualized and unmediated control over the interface whereas the traditional mouse and keyboard setup has an additional barrier between the user and on-screen objects. All of the adolescents in our testing sessions manipulated the virtual game pieces well and demonstrated effective control over the interface. Our evaluation did not reveal any sensory or motor issues related to our user group that inhibited the functional use of tabletop technology. All participants were high-functioning and none had motor coordination difficulties that would significantly impact the use of a traditional computer workstation with a keyboard and mouse. Adolescents with Autism Spectrum Disorders vary in sensory tolerance and motor ability levels, so it is important to evaluate an adolescent's ability to use tabletop technology on an individual basis.

8.1.3 Human- versus Computer-Enforced Rules

Computers provide reliability and consistency in rule enforcement which is particularly useful for these adolescents who find comfort in predictable rules and environmental conditions. Rule enforcement by a human moderator in SIDES and traditional board games can often be subjective and add challenge to an already difficult task, thus making computer-enforced rules a compelling aspect of tabletop games for this audience. The students' therapist commented, "These kids generally do better with rote, impersonal, nonsocial instructions. That's why they do well with computer games. There's no variance, so they don't have to worry about social conventions or social rules." When asked to compare how his students performed in the conditions with computer-enforced rules and human-enforced rules, the therapist replied:

> "It's hard because I thought that they did better without me and my input. I tried to get them to think about strategy, but there was so much stimulus and enjoyment in the game that they didn't listen to me! They had to respond to an adult when I was facilitating it. The computer rules version eliminates one social interaction that they otherwise would have to attend to… Just listening to the game, which is more objective, made playing easier."

8.1.4 Embedded Structure

A mechanism to decentralize control, *voting buttons* in the case of our design, can encourage users to collectively own the process of finalizing and testing a solution. While one player often suggested that the group test the solution, the voting buttons required all group members to come to consensus, encouraging discussion and compromise around changing the state of the game. Our findings also indicate that a turn-taking mechanism (tested with a "give" protocol in Session 2) can reduce an individual's ability to dominate the tabletop activity and take control from others (as illustrated by Group 1 during Sessions 1 and 2). Piece ownership (players could only touch and move their own pieces) provided a way for each student to play a critical role in contributing to the group's solution and creating the path. For example, Brad, a more reserved student in Group 1, received several critical game pieces during various rounds of play. Piece ownership in this case provided him with a chance to contribute key elements to the final product and become more involved in the activity.

Computer-enforced turn-taking combined with restricted access to game pieces necessitates that groups achieve a coordinated state where each player contributes their resources in an orderly fashion to create the final solution. This level of structure worked well for Group 1 but became problematic for Group 2 who was held up by one player who was unwilling to negotiate and trust his teammates' strategy. This student struggled with controlling his frustration when the computer restricted piece movement and he consequently disrupted game play for others by refusing to give up his turn. In this case, the embedded game structure provided additional challenge and hindered the second group's performance. At that point, it would have been interesting for the therapist to try rule variations, gradually reducing structure to determine the most appropriate level of support for this group. In future designs and play sessions, we envision that the therapist is able to adjust the type of rules and how rules are enforced so that students experience a gradual increase in difficulty that is customized to their learning needs.

8.1.5 Need for an Adult Moderator

Involvement of the students' therapist is critical to delivering a customized, cooperative group work experience for these adolescents. Digital tabletop activities, SIDES in particular, are not yet intended to stand on their own as a tool to support effective group work with this audience. The social skills therapist plays a central role in facilitating tabletop activities; his or her presence is required during the session to control behavior and attend to higher-level group work issues. After each play session, the therapist also plays an important role in grounding the learning experience in the social skills concepts discussed in class, which can seem extremely abstract to these students. Through discussion of the activity immediately following game play and even up to weeks later in class, the therapist helps students reflect on the activity and tie abstract classroom topics into this shared real world experience. "The key is to give [the students] experiences to trust themselves, trust their abilities to interact so that generalizes to interacting with other kids in other settings… The goal is generalizing the experience," explained the therapist. SIDES provided a rich and meaningful shared experience that the social skills therapist was able to leverage during classroom discussions, thus revealing the potential for supplementing current classroom activities with an exciting and supportive tabletop computer gaming experience.

8.1.6 Challenges in Participatory Design

Participatory design was critical to designing a motivating experience for this audience and exploring the potential for tabletop computer applications to facilitate effective group work among these adolescents. However, involving adolescents with AS, their parents, and therapists in the design process presented challenges. We share some of our experiences in light of other research on participatory design with special needs groups to inform future work within this discipline.

As previous research on participatory design with special needs groups indicates (e.g., [14]), getting cooperation and assistance from existing groups who cater to the target population and gaining practical experience with the target population was invaluable to our design process and system evaluation. Identifying and receiving entry into an existing group of adolescents with AS, specifically a middle school classroom, was difficult. Obtaining permission to observe this classroom and involve students in our research was an extremely delicate subject and required multiple layers of approval. Many of the students we observed and interviewed had not been informed by their parents of their diagnoses. We faced issues receiving parental consent and initial "buy in" on our project for this reason. It took months to build rapport with this group of students and their parents. This required talking extensively with parents before student interviews and allowing parents to review our interview protocol (per their request) to ensure that nothing we covered would upset their child.

Once we received school, teacher, parental, and student permission, we had another set of challenges to overcome with conducting observations and interviews with this small group of students; we would often arrive at the classroom to find that the student with whom we had worked for several weeks to get an interview scheduled and approved would be in a "bad mood" according to teachers and unwilling to cooperate. Traditional one-on-one interview situations were less successful than we had hoped due to communication and behavioral issues with students. We learned to be flexible in our methods without compromising data validity. For example, we shifted from conducting single person interviews to a group format where students could discuss ideas.

Wu et. al. [25] recommend implementing specific techniques to directly support the challenges inherent to the target user group. For our user population, feeling comfortable in a new environment and avoiding over-stimulation were primary challenges. To address these issues, we spent months building rapport with these students in their classroom environment, encouraged parents to attend the testing sessions at our university, and structured our testing sessions to encourage students to only focus on one task – cooperatively solving the computer puzzle in front of them. Parents were allowed and encouraged to attend testing sessions, as this helped them see the value in our research first hand as well as calm their child if the student became anxious in the new environment.

These day-to-day challenges of conducting participatory design with this audience helped our research team understand how the design of a motivating cooperative skill-building activity could have a far-reaching impact for this population – students, parents, and social skills therapists included.

8.2 Overall Impact

Our work with SIDES reveals the potential for supportive social entertainment applications implemented with tabletop technology to address group work issues among special needs populations. The affinity for technology individuals with AS describe, combined with the ability of computer technology to enforce basic game rules (thus freeing up therapists' time to deal with higher-level group issues), and the flexibility of computer games for adapting content and difficulty level, make tabletop technologies more compelling for this user population than traditional board games. Regarding the students' experience, the therapist commented,

> "It's something they enjoyed doing, so it's not like a lesson where you're teaching them something in traditional lesson form. With the game they're just learning these skills by doing something fun. It's like you're sneaking in learning without them knowing it… It's great that they can feel confident and comfortable while working with each other because it's not torturous. These students didn't even see the activity as learning to work in a group."

Helping students build confidence in their social abilities is another benefit of playing SIDES. For Brad, participating in the testing sessions was an experience far beyond just learning to work in a group. "[Brad] is a kid who has been tormented and terrorized by other kids in his class. For him to be able to participate and feel like he's part of the group and accepted was great. He probably enjoyed it more than anyone because his existence was validated through the shared activity," commented the therapist. On both an individual and class-wide level, we observed the positive effects of situating a topic that is traditionally difficult for this group of students, learning effective group work skills, in an exciting and comfortable context: playing a cooperative tabletop computer game.

9. CONCLUSION

We have presented a design case study of a cooperative tabletop computer game for a special needs population. SIDES provides adolescents with Asperger's Syndrome with a positive experience through which they can develop effective group work skills and build confidence in social interaction. This work provides a starting point for thinking more broadly about user populations and computing scenarios that can benefit from the social computing experience provided by tabletop technology. Through our design process, we thought critically about how the unique social benefits of tabletop technology could benefit this population and crafted an application to support the needs of this group. We believe cooperative computer games are a new paradigm for teaching effective group work skills in a meaningful way and that tabletop technology is a promising tool for facilitating cooperative gaming experiences geared for this special needs population as well as the general public.

10. ACKNOWLEDGMENTS

We thank MERL for donating a DiamondTouch table, and David Perlstein, Dr. Carl Feinstein, Dan Gillette, and Bob Regan for their support of this work. We would also like to offer a special thank you to the students and parents who helped design, test, and evaluate SIDES.

11. REFERENCES

[1] Baron-Cohen, S. (2004). Mind Reading: The Interactive Guide to Emotions (CD-ROM). Jessica Kingsley Publishers.

[2] Bauer, S. (1996). Asperger Syndrome. http://www.udel.edu/bkirby/asperger/

[3] Beardon, L., Parsons, S. & Neale, H. (2001). An inter-disciplinary approach to investigating the use of virtual reality environments for people with Asperger Syndrome. Educational and Child Psychology, Vol. 18, No. 2, 53-62.

[4] Cohen, Jacob. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20, 37–46.

[5] Dietz, P. and Leigh, D. DiamondTouch: A Multi-User Touch Technology. *Proceedings of UIST 2001*, 219-226.

[6] Ehlers, S. and Gillberg, C. The Epidemiology of Asperger's Syndrome: A Total Population Study. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. 34 (8), November 1993, 1327 – 1350.

[7] Fischer, G. and Sullivan, J. 2002. Human-centered public transportation systems for persons with cognitive disabilities – Challenges and insights for participatory design. In Proceedings of the Participatory Design Conference (June) Malmö University, Sweden, T. Binder, J. Gregory, and I. Wagner Eds. Palo Alto, CA, 194-198.

[8] Griffiths, M. (1997). Video games and clinical practice: issues, uses and treatments. *British Journal of Clinical Psychology*, 36, 639-41.

[9] Inkpen, K., Gribble, S., Booth, K.S., and Klawe, M. (1995). Give and Take: Children Collaborating on One Computer. Proceedings of CHI '95: Human Factors in Computing Systems, ACM press, pp. 258-259.

[10] Inkpen, K., McGrenere, J., Booth, K.S., and Klawe, M. (1997). Turn-Taking Protocols for Mouse-Driven Collaborative Environments. Proceedings of Graphics Interface '97, Kelowna, BC, May 1997, pp. 138-145.

[11] Kerr, Neale and Cobb. (2002). *Virtual Environments for Social Skills Training: The importance of scaffolding in practice*. ACM SIGACCESS Conference on Assistive Technologies.

[12] Magerkurth, C., Memisoglu, M., and Engelke, T. 2004. Towards the next generation of tabletop gaming experiences. *Proceedings of Graphics Interface 2004*, 73-80.

[13] Mandryk, R. L., Maranan, D. S., AND Inkpen, K. M. 2002. False prophets: Exploring hybrid board/video games. *Proceedings of CHI 2002*, 640-641.

[14] Moffatt, K., McGrenere, J., Purves, B., Klawe, M., The participatory design of a sound and image enhanced daily planner for people with aphasia. *Proceedings of CHI 2004*, 407-414.

[15] Morris, M.R., Morris, D., and Winograd, T. Individual Audio Channels with Single Display Groupware: Effects on Communication and Task Strategy. *Proceedings of CSCW 2004*, 242-251.

[16] Morris, M.R., Piper, A.M., Cassanego, A., and Winograd, T. Supporting Cooperative Language Learning: Issues in Interface Design for an Interactive Table. Stanford University Technical Report, 2005.

[17] Morris, M.R., Huang, A., Paepcke, A., and Winograd, T. Cooperative Gestures: Multi-User Gestural Interactions for Co-located Groupware. Proceedings of CHI 2006, 1201-1210.

[18] Rogers, Y. and Lindley, S. Collaborating Around Large Interactive Displays: Which Way is Best to Meet? *Interacting with Computers*, 2004.

[19] Schuler, D., and Namioka, A. (Eds.) (1993). Participatory Design: Principles and Practices. Hillsdale, NJ: Lawrence Erlbaum Assoc.

[20] Scott, S.D., Carpendale, M.S.T., and Inkpen, K. Territoriality in Collaborative Tabletop Workspaces. *Proceedings of CSCW 2004*, 294-303.

[21] Shen, C., Vernier, F., Forlines, C., and Ringel, M. DiamondSpin: An Extensible Toolkit for Around-the-Table Interaction. *Proceedings of CHI 2004*, 167-174.

[22] Stewart, J., Bederson, B, and Druin, A. Single Display Groupware: A Model for Co-present Collaboration. *Proceedings of CHI 1999*, 286-293.

[23] Team Asperger. (2004). Gaining Face: Facial recognition software. http://ccoder.com/GainingFace/

[24] Vygotsky, L.S. (1978). *Mind in Society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

[25] Wu, M., Baecker, R., Richards, B. Participatory design of an orientation aid for amnesics. Proceedings of CHI 2005, 511-520.