



The acceptability and efficacy of an intelligent social tutoring system



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ABSTRACT

This study tested the acceptability and efficacy of an innovative intelligent tutoring system (ITS), *Adventures Aboard the S.S. GRIN*, that translates the evidence-based in-person Social Skills Group Intervention (*SSGRIN*) into an interactive game-based social tutorial. This randomized controlled pilot trial tested the first half of the social tutorial software for children with social skills challenges. Participating children in grades 3–5 were randomly assigned to immediate treatment ($n = 19$) or wait-list control ($n = 17$). User ratings indicated the software was easy to use and well-liked for this audience. The program was also associated with observable changes in social skills and behavior; children who interacted with *Adventures Aboard the S.S. GRIN* exhibited lower psychosocial distress and higher behavioral and emotional strength at post-test compared to children who did not. This pilot study offers important insights about the feasibility and potential effectiveness of online social skills training and lays the groundwork for future full-scale effectiveness testing. The advantages of using this state-of-the-art approach and its implications for improving social, emotional, and academic outcomes are discussed.

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1. Introduction

1.1. Social skills are crucial for success

There is growing recognition that social skills are critical for success both in school and in life. Strong support for social skills education is shared by the public, educators, and policymakers alike (Camilli, Vargas, Ryan, & Barnett, 2010; Meier, DiPerna, & Oster, 2006; National Association for the Education of Young Children, 2009; National Research Council, 2012). Gallup Poll results indicate that a majority of people think these skills should be taught to children (Bushaw & Lopez, 2013), and this opinion is increasingly being reflected in state and federal policies (Dusenbury, Zadrizil, Mart, & Weissberg, 2011; HR 1875, 2013). Parents, educators, mental health professionals, and others invested in the development of children and youth are seeking tools to promote positive social development.

There is good reason for this increasing emphasis on social competence. Children who struggle with social skills are at heightened risk for a wide array of externalizing and internalizing problems and serious negative outcomes, including aggression, anxiety, bullying, depression, and substance abuse, as well as academic failure and school dropout (DeRosier, Kupersmidt, & Patterson, 1994; Dodge & Crick, 1990; French & Conrad, 2001; Hawkins, Catalano, & Miller, 1992; Kupersmidt & DeRosier, 2004; Najaka, Gottfredson, & Wilson, 2001; Olweus, 1993; Parker, Rubin, Erath, Wojslawowicz, & Buskirk, 2006; Solberg, Olweus, & Endresen, 2007; Spooner, 1999; Weiss & Hechtman, 1993). Unaddressed problems with peers tend to worsen over time, and as these problems become more chronic and severe the likelihood of serious negative consequences in adolescence significantly increases (DeRosier et al., 1994; Kupersmidt & DeRosier, 2004; Parker et al., 2006).

1.2. Social skills training

Fortunately, social skills training (SST) can improve outcomes for children who struggle. Scores of studies support the efficacy of these interventions for improving children's social skills and academic functioning, and for reducing aggression, mental health problems, and

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substance use (e.g., Beidel, Turner, Young, & Paulson, 2005; DeRosier, 2004; Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011; Foster & Bussman, 2007; Hawker & Boulton, 2000; Joseph & Strain, 2003; Losel & Beelmann, 2003; Zins, Weissberg, Wang, & Walberg, 2004). Effective universal or targeted interventions can help children learn and practice the social skills that increase positive and/or inhibit negative social interactions (Asher & Renshaw, 1981; Coie, Dodge, & Kupersmidt, 1990; Dodge & Feldman, 1990; Merrell & Gimpel, 1997). For example, SSTs directly teach cooperative skills that promote companionship and decrease domineering or impulsive behaviors. Similarly, SSTs enhance empathetic behaviors that promote communication and the ability to take another's perspective.

Unfortunately, the reach of traditional in-person SST is limited (Mueser & Bellack, 2007). Logistical barriers, such as the need for trained professionals to administer the program, financial costs to families, and time and travel requirements for children to participate, mean that many children who could benefit from SST never receive intervention. The families of children in need of social intervention may lack the means to access such treatment, or be unable to commit the time or resources required for in-person intervention. Even when individuals can afford and access traditional SST, in-person treatment delivery often does not provide the repeated opportunities for skill practice and concept exposure shown to result in greater intervention benefits (Foster & Bussman, 2007; Greenberg, Domitrovich, & Bumbarger, 2001), including extending learning and practice opportunities beyond the group setting (Greenberg et al., 2001). The opportunity to not only address these barriers but also offer an unprecedented level of individualized, adaptive intervention is now available, as advances in emergent technologies are making it possible to translate evidence-based SST programs into broadly accessible engaging game-like platforms.

1.3. Intelligent tutoring systems for social skills training

An Intelligent Tutoring System (ITS) is a computer-based learning system that attempts to adapt to the needs of learners (Self, 1999). ITSs foster and assess learning through adaptive interaction between the student and the system, and the instruction contains both domain-specific pedagogical knowledge and knowledge of the learner (Bordeau & Grandbastien, 2010; Collins & O'Brien, 2011). As the learner interacts with the software, the software responds by selecting the most appropriate content and pedagogical style for that learner; in this way, the software reacts in much the same way a human tutor would. The active engagement through interactivity between a child and the software can enhance learning and memory beyond more passive instructional methods (e.g., Corbett, Koedinger, & Hadley, 2001; Graesser, Jeon, & Duffy, 2008).

ITSs offer an innovative way to advance SST, address barriers to effective implementation, and reach children on a much broader scale than traditional methodologies. In effect, ITSs for SST have the potential to lower cost, eliminate the need for travel, accommodate any schedule, and eliminate inconsistencies in treatment delivery across different providers. Beyond these practical benefits, ITSs can improve upon traditional SST models by providing repeated and unlimited practice opportunities within an intelligent, interactive learning environment that can individualize instruction at a level not typically possible with in-person SST. Specifically, ITS software has the capacity to adjust to a child's individual needs by varying difficulty based on performance and providing immediate personalized feedback and pedagogical assistance to guide the child towards target learning goals (Hutcherson, Langone, Ayers, & Clees, 2004; Mazzotti, Test, Wood, & Richter, 2009).

An additional advantage of interactive game-like ITSs is that they are inherently engaging and motivating for today's children, for whom technology has become a ubiquitous part of life (Fitzgerald, 2005; NCREL & Metiri Group, 2003). Learning through virtual or simulated environments can be a great motivator in the educational process and a valuable part of learning and development (Joyce, Gerhard, & Debry, 2009; Ke, 2009). An interactive digital environment lets a child think, understand, prepare, execute actions, and adjust strategy as needed (Gee, 2003) by employing simulated situations analogous to those they experience in real life. Employing ITSs for SST offers the opportunity to improve technical capability and clinical practice in SST. It also provides a safe practice environment; practicing fledgling social skills with peers can be risky, but practicing in the virtual environment gives children a safe place to fail and then try again.

Although the use of ITSs for academic skills such as math and science is becoming more commonplace, an ITS for SST is highly innovative, and as a result the research base is just being established. Early results indicate that interactive software may be an effective tool for remediating social skills for children. To date, most of the available research (e.g., Golan & Baron-Cohen, 2006; Sansoti & Powell-Smith, 2008) has focused on children with autism spectrum disorders, who experience marked social skill deficits, and most of the existing programs are simplistic in design and implementation with little to no dynamic adjustment in difficulty or personalized feedback. One recent system designed to promote social skills and prevent bullying called *Quest for the Golden Rule* (Rubin-Vaughan, Pepler, Brown, & Craig, 2011) includes more complex social problem solving situations, and preliminary results look promising. However, because that research did not include a control group, it's not possible to draw conclusions about the effectiveness of *Quest for the Golden Rule*.

1.4. Adventures aboard the S.S. GRIN

1.4.1. Social skills group intervention: the evidence-based in-person program

The primary goal of the interactive program is to enable broad delivery of an evidence-based SST and provide children with a safe and private learning environment in which to build and practice social skills through interactive social problem solving (SPS) scenes. The specific skills included were based on *Social Skills Group Intervention (SSGRIN)*, an evidence-based in-person SST program. Developed at 3C Institute and currently used with thousands of children across the United States and abroad, *SSGRIN* has been repeatedly tested resulting in a strong empirical base for its effectiveness (e.g., DeRosier, 2004; DeRosier & Gilliom, 2007; DeRosier & Marcus, 2005).

SSGRIN is a 10 week in-person small group intervention for children with social skills deficits, led by a trained professional (e.g., psychologist or school counselor). *SSGRIN* is designed to be broadly applicable to children experiencing a wide range of social difficulties, including immature social skills relative to same-aged peers; social isolation with few close friends; rejection, teasing, or bullying by peers; social anxiety or awkwardness with peers; aggressive or bullying behavior with peers; and impulsive, disruptive behaviors. The program addresses the five social and emotional learning (SEL) competency clusters identified by CASEL (2013), which include self-awareness, self-management, social awareness, relationship skills, and responsible decision making. It focuses on increasing children's capacity to evaluate social situations and respond in an adaptive, prosocial manner to achieve social goals. Children who participate in *SSGRIN* show increased

social skills knowledge, social problem solving, social acceptance, self-esteem, and emotional functioning, as well as lower depression, anxiety, and aggressive behavior (DeRosier, 2004, 2007; DeRosier & Marcus, 2005).

1.4.2. Program description and development

To develop the ITS *Adventures Aboard the S.S. GRIN*, we translated the *SSGRIN* curriculum into a game-like instructional program by designing in-game tasks that required children to apply specific social skills in order to solve each social problem encountered. The translation was done by a Developmental Psychologist (Ph.D.) with expertise in children's emotional development, and reviewed and approved by the developer of the original curriculum, Dr. Melissa DeRosier. Developed for children in grades 3–5 (aged 8–12 years) who struggle with social skills, the game-like program was designed to actively engage children in social problem solving tasks through interactive software technology, and reflects best practices for children's educational interactive software (e.g., Garris, Ahlers, & Driskell, 2002; Mathan & Koedinger, 2002; Roussou, 2005).

To develop the interactive game *Adventures Aboard the S.S. GRIN*, we designed the SPS scenes upon the foundations of general problem-solving models and cognitive-behavioral therapy (e.g., Bloomquist, 2005), as well as decades of theory and research in children's social development (e.g., Bandura, 1977; Crick & Dodge, 1994; Parker et al., 2006). We incorporated research-supported SST strategies such as increasing social knowledge, practice with personalized feedback, and positive reinforcement (Elliott & Gresham, 1993) and incorporating behavioral (i.e., what to do or not do in a social situation), cognitive (i.e., assumptions, evaluating consequences, goal setting), and emotional (i.e., self-awareness, emotion regulation) social skills into instruction (Asher, Parker, & Walker, 1996; Graczyk et al., 2000). This integrative approach helps children think through a given social situation, consider alternative social problem solving approaches, and evaluate the success of a selected approach for achieving a social goal. Interventions that use these strategies to build children's capacity to actively engage in social problem solving have the most significant and lasting impact on the quality of their social relationships (Greenberg, Kusché, & Riggs, 2004; Kam, Greenberg, & Kusché, 2004; Suveg, Southam-Gerow, Goodman, & Kendall, 2007). Examples for specific social skills addressed in each episode and examples of their in-game interactions are shown in Table 1.

An interdisciplinary team of psychologists, computer programmers, and artists collaborated to create an engaging learning environment to serve as the context for social problem solving. We decided to develop *Adventures Aboard the S.S. GRIN* as a single player game rather than a multiplayer game for a number of reasons. A single player game enabled individualized feedback and play paths based on player choices, allowed for control over the reactions of other characters in a game, created a safe environment in which to practice fledgling skills without social ramifications, and avoided the possible iatrogenic effects of participants reinforcing negative behaviors in other children.

The point-and-click problem solving tutorial provides a game-like feel due to the story arc, characters, and computer interaction. A compelling storyline and engaging challenges have been found to be critically important for engaging children in instructional software (Mott & Lester, 2006a, 2006b; Roussou, 2005), and this consideration was significant in the development of the program. The story world is based on a nautical adventure theme in which the player is a new recruit on the sailing ship S.S. GRIN and joins an established crew, each of whom specializes in a specific social skill (e.g., impulse control). The narrative purpose of the crew members is to be the child's companions, but the tutoring system also employs them as pedagogical agents to provide feedback and assistance as needed. When the child first uses the software, he/she creates a customized avatar to represent himself or herself in the game. Using this avatar, the child then navigates the virtual environment, interacting directly with non-player characters (NPCs) and learning to appropriately manage social challenges. Specifically, the child's avatar must join the crew and travel around an island engaging in social problem solving in order to address plot conflicts and save friendship on the island.

As children navigate the program, the software captures in-game behaviors. Some of these behaviors are dialog-driven menu choices, whereas others are game-based behavior (e.g., if a child is asked to help with a task, does the child comply or choose another action, such as walking away?). The difficulty level of the social tasks increases both within and across the nine episodes of the game. For example, an early episode addresses relatively simple choices that show self-respect and respect for others, whereas a later episode addresses the skills needed to initiate positive social interactions, including the complex interaction of respect, observation, communication, thinking out options, and considering consequences. Within the "initiation" episode participants move from a relatively easy scenario (initiating with one non-intimidating other) to a more difficult one (initiating with two characters who are already engaged with each other) to an even more difficult scenario (initiating with a group of friends who appear intimidating and reject initial attempts).

Table 1
Description of episodes 1–4 of the *Adventures Aboard the S.S. GRIN ITS*.

Episode	Topic	Goals	Examples
1	Respect	Demonstrate respect for self and others.	<ul style="list-style-type: none"> - Players teach one character how to respectfully interact with another. - Players face two challenges (one they successfully complete and one they do not) and learn to accept help and appropriately express pride.
2	Consequences, Role Models, and Goals	Identify long- and short-term consequences. Identify good role model qualities. Create and use an action plan to reach a goal.	<ul style="list-style-type: none"> - Players are given a tempting but irresponsible choice. Later in the episode, they experience the consequence of their decision. - Players program a role model robot by choosing whether or not a variety of statements represent qualities of a good role model.
3	Responsibility and Stop and Think	Identify and follow through with responsible actions. Stop and think about how consequences relate to choices.	<ul style="list-style-type: none"> - Players are given a responsibility and then choose to either follow through or deflect the responsibility onto another character. - Players help two characters resolve a conflict by matching several possible actions with their likely consequence, and then choosing the best option.
4	Communication	Demonstrate understanding of verbal and nonverbal communication.	<ul style="list-style-type: none"> - Players solve a puzzle that requires listening carefully to another player for clues. - Players navigate a maze by attending to body language, facial expression, and tone of voice to ascertain meaning.

As an ITS, it was essential that the software track players' actions, tailor hints and feedback along the way, collect information on performance, make inferences about players' strengths and weaknesses, adapt to the needs of the learners, and contain the following components: knowledge of the domain, knowledge of the learner, knowledge of appropriate pedagogy, and interactive environment interface (Samuelis, 2007). Central to the development of the program, we ensured that the program adapted to the needs of the players by monitoring progress in real time and adjusting gameplay accordingly. The software monitored individual progress and responded with appropriate content, feedback, and pedagogical assistance based on player actions. We incorporated proven training strategies of scaffolding, coaching and reinforcement, and practice to create an effective social learning program for children. For example, in one task the player needs to complete a mission that initially appears possible to complete alone, but reveals itself to be a two-person job. Without explicit instruction, the player needs to seek the cooperation of an NPC. If the player does not perform this action in a given amount of time, an NPC walks through the scene as a hint that help is available. If the player still does not seek assistance after a given amount of time, the NPC reminds him or her that help is available. Finally, if the player is still attempting the impossible task, the NPC reappears to help and provides information about cooperation and help-seeking. At appropriate times, individualized feedback is provided in response to the child's performance, and when gameplay indicates that a skill has not been satisfactorily demonstrated the child is provided structured guidance, and in some cases is asked to continue to practice the skill in-game until he or she demonstrates an understanding of a good social choice. Achievements are provided for outstanding performance, and players are able to replay episodes to earn all achievements. All text-based dialog is accompanied by audio voiceover to account for differences in reading ability and to convey important social information, such as emphasis and tone of voice.

In order to test the potential promise of this innovative computerized method for SST, we examined the impact of participation in the first half of the software through this study. In particular, we were interested in examining how children and families use the program outside of a clinical environment in order to determine its feasibility, usability, and potential efficacy as a broad-scale SST tool. The tested portion of the ITS included four instructional episodes, each of which focused on a specific social skill (i.e., respect, social planning, impulse control, and communication). Children completed 38 rooms (i.e., discrete visual spaces), interacted with 42 unique characters, and completed 14 social problem-solving scenarios for this study, totaling approximately 90 min of gameplay. Sample screenshots from *Adventures Aboard the S.S. GRIN* are shown in Fig. 1 (further examples available at <http://www.3ctechnologies.com/games>).

Our research questions were:

1. Will children with social skills deficits find the ITS likeable and usable?
2. Will interaction with the ITS be associated with reduced psychosocial distress and greater behavioral and emotional strength?

We hypothesized that both research questions would be answered in the affirmative.

2. Material and method

2.1. Participants

Participants were recruited in the spring of 2013 via postings on local parenting listservs, social media sites, and through contacts within area school systems and child service providers. Interested parents completed an online eligibility survey which included demographic information and the Behavior Assessment System for Children, Second Edition (BASC-2; Reynolds & Kamphaus, 2004), a behavior rating scale. To be eligible to participate, participants must have (1) been attending 3rd, 4th, or 5th grade in the fall of 2013; (2) received instruction in a regular education classroom for at least 40% of the school day; (3) been English language proficient; (4) had access to a computer with Internet use at home; and (5) scored at or above the clinical cut-off for their age and sex on any of 14 subscales on the BASC-2, or scored in the "at-risk" range on at least two subscales.

To reduce sampling error, eligible participants were stratified by grade, sex, race, and scores on three BASC subscales (social skills, withdrawal, and aggression). The social skills subscale measures skills children need when interacting with peers and adults, including productive communication and offering to help others in need. The withdrawal subscale examines the tendency to isolate oneself from social interaction, including refusing to talk and preferring to be alone. Finally, the aggression subscale assesses the tendency to do or threaten physical or emotional harm to others (Reynolds & Kamphaus, 2004). These three subscales were included for stratification to balance the treatment and control groups because they represent adaptive/maladaptive and internalizing/externalizing social behaviors. Following stratification, participants were randomly assigned to either an immediate treatment condition or a wait-list control condition. Study attrition, defined as failure to complete all four episodes and the pre- and post-test assessments, was 14% ($n = 6$) over the entire data collection period. Chi-square tests revealed no significant differences between participants who completed the program versus those who did not on grade, sex, race, household income, or BASC-2 subscale scores.

Descriptive information regarding the participants for this study ($n = 36$) is presented in Table 2, separately for participants in the treatment and control groups. Chi-square tests revealed no significant differences between participants in the two study conditions for any variable other than race ($\chi^2 = 3.955, p < .05$). In the treatment group, there were more white participants than non-white (79% and 21%, respectively), whereas in the control group there were slightly more non-white participants than white (53% and 47%, respectively).

2.2. Measures

2.2.1. Usability and likability

Following interaction with each episode of the program, children provided feedback on their experience via an online product evaluation survey. The surveys included pictures from the episode for reference, and children were asked to report how true for them were statements such as "Overall, I liked this whole episode of *Adventures Aboard the S.S. GRIN*," "I thought it was easy to understand how to make my character move or talk," and "I think my friends would like this episode." Response choices were presented on a five-point Likert-type scale

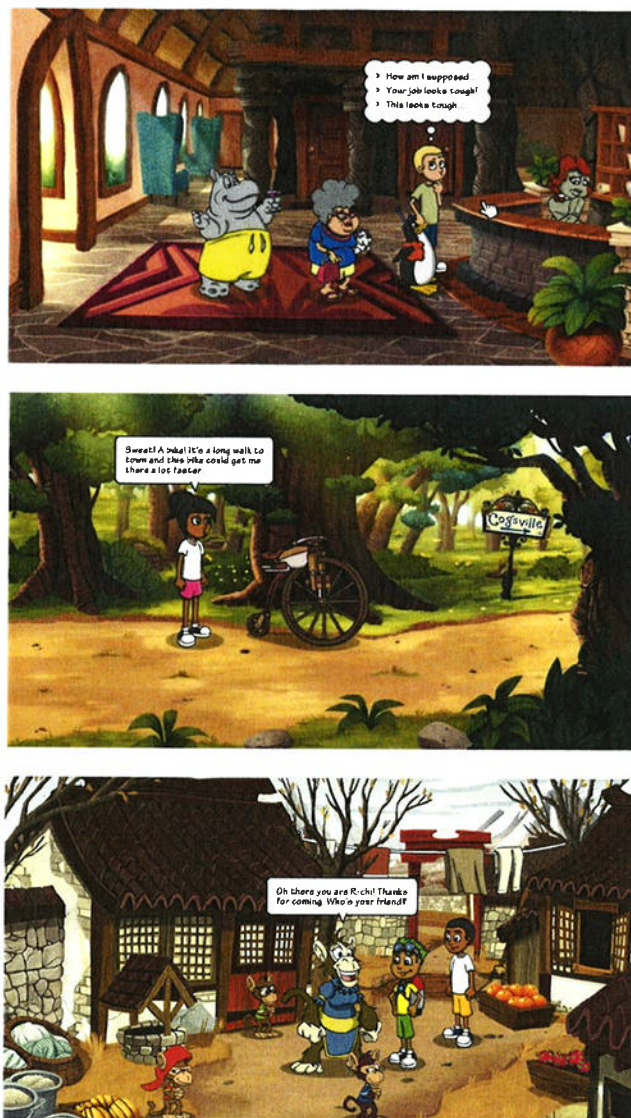


Fig. 1. Screenshots from *Adventures Aboard the S.S. GRIN*.

ranging from 1 (NO!) to 5 (YES!), utilizing faces along with words to represent response options in a developmentally appropriate manner (see Fig. 2). For interpretation and analysis, the response choice scale was translated so that 1 = strongly disagree and 5 = strongly agree.

2.2.2. Psychosocial distress

The Youth Outcomes Questionnaire, Second Edition (Y-OQ 2.01; Burlingame et al., 2005) is a 64 item parent-report measure designed to assess a child's psychosocial distress. The Y-OQ 2.01 consists of six subscales: Intrapersonal Distress, Somatic, Interpersonal Relations,

Table 2
Comparison of demographics and BASC-2 scores by intervention condition.

	Treatment <i>n</i> = 19	Control <i>n</i> = 17
<i>Demographics</i>		
Grade: % 3rd/4th/5th	32/36/32	41/24/35
Sex: % F/M	26/74	28/72
Race: % White/Non-White	79/21 ^a	47/53 ^a
HH Income: % <\$100K/\$100K–\$200K/>\$200K	59/29/12	80/20/0
<i>BASC-2 Scores</i>		
Social skills: % Average/At Risk/Clinical	53/31/16	52/24/24
Withdrawal: % Average/At Risk/Clinical	16/26/58	29/24/47
Aggression: % Average/At Risk/Clinical	42/42/16	41/41/18

^a *p* < .05 for Treatment vs. Control condition.



Fig. 2. Visual representation of response options.

Critical Items, Social Problems, and Behavioral Dysfunction. Parents were asked to report how true statements (e.g., “Seems anxious or nervous,” “Doesn’t have or keep friends,” “Acts impulsively, without thinking of the consequences”) were for their child during the past seven days on a 5-point Likert-type scale ranging from 0 (never or almost never) to 4 (almost always or always). Scores for each subscale are computed by summing the scores for all items in the subscale. The Y-OQ 2.01 Total is a composite score computed by summing scores on all subscales. Higher scores on the Y-OQ 2.01 Total and on each subscale indicate higher levels of psychosocial distress. The Y-OQ 2.01 has high reliability (Cronbach’s $\alpha = .97$) and its publishers detail several studies establishing the content, criterion-related, and construct validity with both clinical and non-clinical (community) samples (Burlingame et al., 2005). We selected it to measure the effects of the ITS because of its utility as a global measure of observed behavior change over relatively short periods of time (Burlingame et al., 2005).

2.2.3. Behavioral and emotional strength

The Behavioral and Emotional Rating Scale, Second Edition (BERS-2; Epstein, 2004) is a 57 item strength-based assessment that measures the positive emotions, behaviors, and aspects of an individual’s life. The BERS-2 consists of five subscales: Interpersonal Strength, Family Involvement, Intrapersonal Strength, School Functioning, and Affective Strength. Parents were asked to think about their child’s status over the past thirty days and report how much statements such as “participates in family activities,” “identifies own feelings,” and “shares with others” were like their child. Response choices were on a 4-point Likert-type scale ranging from 0 (not at all like your child) to 3 (very much like your child). Raw scores for each subscale are computed by summing the scores for all items in each scale. Subscale raw scores are then converted into standard scores. Finally, the BERS-2 composite score, called the Strength Index, is calculated by summing the scaled scores and converting to a standard score. Higher scores on the subscales and on the composite Strength Index reflect greater behavioral and emotional strength. The BERS-2 has demonstrated very good reliability (Cronbach’s $\alpha = .97$), and factor analyses have established content-description, criterion-prediction, and construct-identification validity (Epstein, 2004). We selected the BERS-2 for this study because of its utility as a measure of treatment effects for interventions designed to enhance a child’s behavioral and emotional strengths (Epstein, 2004).

2.3. Procedure

Precautions were taken to ensure study ethics and protection of human subjects. The study protocol was approved by an institutional review board, and verbal assent (from children) and written informed consent (from parents) was obtained from all participants prior to participation. All parts of the study were completed online through the secure project website. Prior to completing pretest measures and beginning the intervention, all participants viewed a welcome video explaining the study design and timeline, and training them in the use of the project website and the *Adventures Aboard the S.S. GRIN* computer program.

All parents completed the BERS-2 and YOQ 2.01 as pretest measures. The week following pretest data collection, the treatment group began interacting with the *Adventures Aboard the S.S. GRIN* ITS. Episodes were released weekly for four weeks, and children had one week to complete each episode. There were three steps to each week’s activities: (1) participants played through the episode, (2) participants completed the episode quiz and mini-game, and (3) participants completed the product evaluation survey. The episode quiz reviewed the concepts and skills covered in each episode, and by playing the quiz participants were able to earn tokens which they used to play mini-games. Mini-games were included to increase engagement and provide a reward to children for completing the episode and quizzes.

Following the treatment group’s four week interaction with the ITS, parents in both groups completed the BERS-2 and the YOQ 2.0 again. Once posttest data collection was completed, the wait-list control group received the *Adventures Aboard the S.S. GRIN* computer program to interact with as they wished.

3. Results

Our first research question was whether children with social skills deficits would find *Adventures Aboard the S.S. GRIN* likeable and useable. If children were unable or unwilling to independently and effectively use the program, its value as a social skills tutorial would be greatly reduced. We hypothesized that usability and likability would both be rated highly by participants, and these hypotheses were supported. Results are shown in Table 3 and described below.

3.1. Usability

Children found the program to be understandable and usable, supporting our first hypothesis. It was important to ensure that children understood how to interact with *Adventures Aboard the S.S. GRIN* because the program would be ineffective as a social skills intervention tool designed for nonclinical settings if the program design precluded its independent use by children. For the purposes of this study, children answered a series of questions related to the ITS mechanics and their understanding of the program. Children answered the following questions regarding usability for each part of each episode, and for each episode overall: (1) I thought it was easy to understand what to do next; (2) I thought it was easy to understand what the characters were saying; (3) I thought it was easy to understand how to make my character move or talk. Results showed that children understood the program in terms of gameplay mechanics, the characters’ speech, and

Table 3
Descriptive statistics for treatment group participants ($n = 19$).

	<i>M</i>	<i>SD</i>
Usability		
Understood characters' speech	4.45	.23
Understood how to move and talk	4.47	.21
Understood what Avatar should do next	4.18	.13
Likability		
Liked program overall	4.39	.18
Thought program was fun to play	4.46	.15
Liked characters	4.40	.09
Liked art and graphics	4.47	.07
Would like to play more programs like this	4.40	.14
Friends would like to play this program	4.12	.14
Would like to play this program again	4.05	.11

Note. The usability and likability values represent combined mean percentages for the first four episodes of the program. 1 = strongly disagree, 2 = disagree, 3 = Neither agree nor disagree; 4 = agree; 5 = strongly agree.

how to select their Avatar's speech and actions. These findings assured us that the gameplay was not an obstacle to successful transmission of social skills instruction.

3.2. Likeability

Children also enjoyed the program, supporting our second hypothesis. The degree to which children enjoy an ITS such as *Adventures Aboard the S.S. GRIN* affects whether and how much they interact with the program. Because this program was designed to be played by children independently outside of a clinical setting, and because greater practice of social skills (i.e., dosage) is associated with greater skills gains, it was important for us to determine whether children enjoyed their interactions with the program. Immediately after completing each episode, children answered seven questions to assess the degree to which they liked interacting with the program: (1) I liked this episode; (2) I thought this episode was fun to play; (3) I liked the characters; (4) I liked the pictures/graphics; (5) I would like to play more programs like this one; (6) My friends would like to play this episode; (7) I would like to play this episode again. Results revealed that children enjoyed the program very much and gave the program high scores across all likability areas assessed. Knowing that the participants both understood and liked the program, we next turned our attention to the efficacy data.

3.3. Psychosocial distress

Once the usability and likeability aspects of the program were established, we investigated our second research question: whether interaction with the ITS would be associated with reduced psychosocial distress and increased behavioral and emotional strength. We hypothesized that they would be, and our hypothesis was supported. Descriptive statistics are presented in Tables 4 and 5, and results are described below.

We examined the relation between interacting with the program and psychosocial distress scores through the following three methods.

3.3.1. Significant change scores on the Y-OQ 2.01

To highlight the practical significance of our findings, we calculated the number of children within each group who had significant changes in scores as provided in the measure's manual across each of the six subscales of the Y-OQ 2.01, and for the total Y-OQ 2.01

Table 4
Percentage of participants in each group demonstrating significant changes on the Y-OQ 2.01.

Y-OQ 2.01 subscale	Treatment group ($n = 19$)	Control group ($n = 17$)
Intrapersonal distress		
Improved	42%	35%
Deteriorated	0%	0%
Somatization		
Improved	11%	6%
Deteriorated	0%	0%
Interpersonal relations		
Improved	21%	12%
Deteriorated	11%	0%
Social problems		
Improved	0%	0%
Deteriorated	0%	0%
Behavioral dysfunction		
Improved	29%	12%
Deteriorated	0%	0%
Critical items		
Improved	26%	24%
Deteriorated	0%	6%
Y-OQ 2.01 Total score		
Improved	68%	52%
Deteriorated	0%	0%

Table 5
Percentage of participants in each group demonstrating significant changes on the BERS-2.

BERS-2 subscale	Treatment group (n = 19)	Control group (n = 17)
Interpersonal strength		
Improved	26%	24%
Deteriorated	0%	12%
Family involvement		
Improved	16%	12%
Deteriorated	0%	12%
Intrapersonal strength		
Improved	26%	0%
Deteriorated	0%	0%
School functioning		
Improved	26%	12%
Deteriorated	26%	18%
Affective strength		
Improved	42%	.12%
Deteriorated	0%	6%
Total strength index		
Improved	16%	12%
Deteriorated	0%	18%

psychosocial distress index. "Significant change" is a reliable change index used to determine if the change exhibited by an individual is clinically significant; individuals' scores must change by a minimum amount based on analyses of norm data by the measure's developer in order to be considered significantly different from pretest to posttest. These results are displayed in Table 4. Relative to the control group, more children in the treatment group had significant improvement across each subscale and on the overall Y-OQ 2.01 index score.

3.3.2. Testing treatment effects on the Y-OQ 2.01 with ANCOVA

Outcomes for the treatment and control group participants were compared using a one-way ANCOVA, with treatment condition as the independent variable (i.e., the treatment group completed four episodes of *Adventures Aboard the S.S. GRIN* over a four-week period, and the control group did not interact with the program) (Cohen, 2001; Field, 2005; Keselman et al., 1998). There is substantial support in the literature for using ANCOVA when groups do not differ significantly on the covariate (e.g., Miller & Chapman, 2001) and when the research question is whether posttest means, adjusted for pretest scores, differ between the two conditions (Sweet & Grace-Martin, 2011). Posttest Total Score on the Y-OQ 2.01 was the dependent variable, with pretest Total Score on the Y-OQ 2.01 as the covariate. All tests were conducted using Sidak adjusted alpha levels to account for multiple comparisons (Field, 2005).

The covariate, Y-OQ 2.01 Total Score at pretest, was significantly related to parent-reported psychosocial distress at post-test, $F(1, 34) = 194.285, p < .001, r = .923$, showing the expected finding that children with higher scores at pretest also had higher scores at posttest. We included pretest score as the covariate to remove the variance associated with pretest scores and determine whether playing *Adventures Aboard the S.S. GRIN* contributed significantly to the variance in Y-OQ 2.01 Total Scores at posttest when controlling for pretest scores. We found that participants in the treatment group evidenced significantly lower psychosocial distress at post-test ($M = 23.32, SD = 18.79$), compared to those in the control group ($M = 48.71, SD = 42.16$) after controlling for pretest psychosocial distress scores, $F(1, 34) = 4.131, p = .05$.

Lastly, we calculated effect sizes using *t*-statistics, based on Field's (2005) recommendation against using η^2 or ω^2 with unequal numbers of participants in the two experimental conditions. The strength of the relationship between playing *Adventures Aboard the S.S. GRIN* and Y-OQ 2.01 posttest scores was moderate ($r = .329$), according to Cohen's (1992) conventions. This result, combined with the change scores presented in Table 4, indicates that interaction with the program led to lower psychosocial distress.

3.4. Behavioral and emotional strength

We followed the same statistical procedures as for the Y-OQ 2.01 analyses, first comparing the numbers of participants in each treatment condition who exhibited a significant pretest to post-test change in scores on the BERS-2, and then conducting a one-way ANCOVA to further investigate the effects of playing *Adventures Aboard the S.S. GRIN*. Alpha levels were again Sidak adjusted to account for multiple comparisons, per Field's (2005) recommendation.

3.4.1. Significant change scores on the BERS-2

We calculated the number of children within each group who had statistically significant changes in scores across each of the five subscales of the BERS-2, and for the BERS-2 Total Strength Index. Per the BERS-2 manual, this indicates the children within each group who had significant changes in scores as determined by the standardized test scores and the normal distribution (i.e., scores must change by more than one standard deviation from the mean to be determined significantly different from pretest to posttest). As shown in Table 5, more children in the treatment group than in the control group had significant improvements across all subscales and on the overall BERS-2 index score. With the exception of the School Functioning subscale, no children in the treatment group exhibited significant deterioration in any areas assessed by the BERS-2, whereas in the control group there were children with significant declines in scores across every subscale. It should be noted that because all data collection occurred in the summer, school functioning results should be interpreted with caution.

3.4.2. Testing treatment effects on the BERS-2 with ANCOVA

A one-way ANCOVA was conducted to assess the relation between playing *Adventures Aboard the S.S. GRIN* and behavioral and emotional strength. The independent variable, treatment condition, included the treatment level and control level. The dependent variable was

parent-reported emotional and behavioral strength at posttest, as measured by the BERS-2 Total Strength Index. The covariate, BERS-2 Total Strength Index pretest score, was significantly related to parent-reported emotional and behavioral strength at post-test, $F(1, 34) = 74.422$, $p < .01$, $r = .686$, indicating that, as expected, children's scores at pretest were related to their scores at post-test. We included pretest scores on the BERS-2 Total Strength Index as a covariate in order to account for this confounding variable and obtain a more pure measure of the effect of this ITS.

Children who played *Adventures Aboard the S.S. GRIN* showed higher levels of emotional and behavioral strength at post-test ($M = 93.21$, $SD = 13.41$) relative to children who did not interact with the program ($M = 86.94$, $SD = 19.61$) after controlling for the pre-test strength scores, $F(1, 34) = 5.352$, $p < .05$, $r = .136$. This finding, combined with the change scores presented in Table 5, indicates that interaction with *Adventures Aboard the S.S. GRIN* led to significant improvement in emotional and behavioral strength. This effect size represents a small effect according to Cohen's (1992) conventions.

4. Discussion

The goal of the current study was to investigate the viability of leveraging gaming technology to advance mental health service delivery by reaching beyond current in-person SST delivery models. We tested whether children with social skills challenges in grades 3–5 would like and be able to independently use the program *Adventures Aboard the S.S. GRIN*, and whether use of the program was associated with positive changes in psychosocial distress and behavioral and emotional strength. The instructional goals and approach of the program were based on *SSGRIN*, an evidence-based, in-person group social skills program designed to help children who struggle with peer relationships learn the skills needed to enhance their social behavior and relationships. The in-person program has been proven successful in small group settings when administered by a trained professional (DeRosier, 2004; DeRosier & Gilliom, 2007; DeRosier & Marcus, 2005), and our goal was to extend the effective delivery of this program through the use of technology. By using a randomized controlled trial design, we were able to gather evidence of the promise of this new intervention modality for enhancing social learning and behavior.

A persistent challenge in the design and creation of educational games is the balance between entertainment, demandingness, and instruction. The acceptability of a program, as measured by likeability and usability, is important to assess because if the program isn't enjoyable and engaging, children won't meaningfully interact with it; if the level of challenge is too low or too high, children will either be bored or frustrated and learning will be diminished. Program efficacy, as measured by knowledge and/or behavior change is also important to evaluate, because if the program is *too* entertaining there is a risk of the educational goals being overshadowed by the entertainment aspects of the game. Due to the innovative nature of using ITSs for SST, it was important that we assess both acceptability and efficacy of *Adventures Aboard the S.S. GRIN*.

We found that children rated the ITS very highly on acceptability for both likeability and ease of use. These results were highly encouraging, because the nonclinical setting delivery of this program requires child program users to be motivated and able to use the software with little or no intervention in order for it to be effective. The mean ratings for each of the items assessing the extent to which children found the ITS enjoyable and easy to use were between "agree" and "strongly agree." These findings indicate that the program was engaging and appealing to children in grades 3–5. Children indicated that they would like to play the game again, which is encouraging because practicing appropriate social skills is a factor in successful generalization of the skills to new settings.

We also found support for the efficacy of the program, in that interaction with the program was associated with positive, observable behavior change. Children who played *Adventures Aboard the S.S. GRIN* evidenced decreased psychosocial distress and increased behavioral and emotional strength relative to children who did not interact with the program. The effect size for psychosocial distress was moderate, and the effect size for behavioral and emotional strength was small but significant. This significant effect is especially notable given the novel intervention modality of the program and the low dose of intervention. In addition, examination of significant change scores for each subscale of these constructs showed that more children in the treatment group showed positive change on the subscales of intrapersonal distress, somatization, interpersonal relationships, social problems, behavioral dysfunction, critical items, family involvement, school functioning, and affective strength. Taken together, these results provide evidence that children with social skills challenges can benefit from playing *Adventures Aboard the S.S. GRIN*.

4.1. Intelligent tutoring systems for social skills training

The results of this study add to an established body of work showing that effective SST can foster positive behavioral and emotional outcomes. Our findings extend prior research by demonstrating that a game-like ITS can be an effective vehicle for conveying this training. Evidence for the effectiveness of ITSs for SST is growing, although programs tend to focus on more basic skills such as memorization of faces and emotions as opposed to more complex social problem solving scenes, or are limited by experimental design issues.

Our results corroborate and extend the existing evidence in this emerging, innovative field. Preliminary evidence on two bullying prevention interactive computer games hint at the promise of this medium for effective social skills training. Evidence from *Quest for the Golden Rule* (Rubin-Vaughan et al., 2011) shows that children who interacted with the game gave high ratings for enjoyment, and had greater knowledge of bullying and improved identification of strategies to prevent bullying at post-test than at pretest. The quasi-experimental design of the Rubin-Vaughan et al. study, however, prevents causal conclusions about the role of the game in these changes. Evaluation of the effectiveness of the virtual role playing bullying prevention program, *FearNot!* (Hall, Woods, Hall, & Wolke, 2007), did employ a true experimental design and found a decrease in bullying victimization for children who interacted with the program. Our findings add to the body of work in the emerging field of ITS for SST by using a randomized controlled trial design to provide evidence that a SST designed to deliver an evidence-based program for general social skills improvement can lead to observable behavior change, that the program is well-liked by users, and that it is easy for children to use independently outside the clinical setting.

ITSs offer a number of advantages over traditional SST methodologies. As mentioned previously, ITSs mitigate several of the challenges associated with traditional in-person SST (e.g., time, cost, and accessibility) that limit the feasibility of in-person treatment for many individuals. In addition to these practical considerations, ITSs offer other advantages. Children are more engaged and motivated to learn when interacting with educational games as compared to traditional learning environments (Annetta, Minogue, Holmes, & Cheng, 2009; Chandra

& Lloyd, 2008), and a moderate amount of interaction with pro-social computer game content is beneficial to children's academic, cognitive, and social skills (Tran & Subrahmanyam, 2013). Huffert and Calvert (2003) note that because ITSs motivate children to engage in the learning process and encourage self-direction and the application of learning to new situations, they support the critical components of learning. Because ITSs can be presented in an interactive format that presents multiple examples of content over varying levels of difficulty and provides immediate feedback and guidance based on participant responses (Hutcherson et al., 2004; Mazzotti et al., 2009), children are able to work independently and can repeatedly practice scenarios. ITSs also provide a safe environment in which to try out and practice new or different social skills, a task that may be uncomfortable for children to engage in with peers. Working on social skills with peers, even in group therapy sessions, leaves children open to the potentially negative reactions of other children. In ITSs, the reactions of the characters in the program can be controlled so that children are not discouraged from engaging and practicing skills. Emerging technologies may be a viable answer to the challenges of maintenance and generalization associated with social skills interventions, and may motivate learning (Fitzgerald, 2005; Goldsworthy, Barab, & Goldsworthy, 2000).

4.2. Limitations & future directions

This pilot study offers important insights about the feasibility of the online social skills training *Adventures Aboard the S.S. GRIN* ITS, and the efficacy results are very encouraging for the promise of technology-based social skills intervention. It should be noted that efficacy tests are not intended to prove full effectiveness of an intervention, and future development and testing of this promising program will provide more information about its capabilities. Because this study was designed as a pilot efficacy test, our sample size was relatively low, resulting in limited statistical power. As a result, we were constrained to fairly basic statistical methods and were unable to examine potentially informative interactions with variables such as age, sex, and specific social skill deficit. Another consideration is that without an alternate activity for the waitlist control group, the placebo effect is a possibility for observed behavior changes in children in the treatment group. In addition, because the pilot test was conducted over the summer we were unable to assess in-school behaviors. Finally, this study was conducted on the first half of the complete tutorial and as a result we were unable to examine the effects of the full program.

The next step in our research will be the development and large-scale testing of the complete ITS. An additional five instructional episodes targeting specific social skills (i.e., checking assumptions, initiating friendships, cooperation, compromise, and dealing with peer pressure and emotional interference) will complete the program. Once the full ITS is developed, we will conduct a large-scale efficacy trial that will include teacher ratings of children's behavior. Combined with parent and child data, this information will give us a comprehensive understanding of the effects of the intervention. This larger efficacy test will also include a substitute online activity for participants in the waitlist group (e.g., interaction with an academic website) in order to reduce the possibility of placebo effects among the group receiving the intervention.

In the follow-up study with greater statistical power we will also examine effects of the intervention for children of different ages, and for different subtypes of socially struggling children (e.g., aggressive, withdrawn, rejected). In addition, we will explore sex differences in the use, appeal, and effectiveness of the program. We will also examine dosage effects to determine whether additional exposure has added benefits, and if so, for whom. In future studies we also plan to include additional behavioral, emotional, and academic outcome variables to investigate the effects of the intervention across a broad range of child outcomes. A final step in evaluating the efficacy of *Adventures Aboard the S.S. GRIN* will be a comparative study. We will examine how the online program compares not only to a control group, but also to the in-person *S.S. GRIN*, and to a combined SST that includes both the in-person and online aspects of the program. This will enable us to determine the added value of the ITS.

A future phase of our research will include investigating the long term effects of the intervention. The developmental nature of social relationships means that some positive effects of SST may be evidenced after a time delay. For example, an impulsive child who learns to stop and think before reacting can, over time, earn the trust and respect of others. Peers, teachers, and parents can reinforce this appropriate behavior. This may lead to greater peer acceptance, improved self-esteem and family relationships, and better social and academic functioning over time. An investigation of the long term effects of the in-person *S.S. GRIN* program revealed that immediate gains were maintained, and additional positive treatment effects emerged one-year following program participation (DeRosier & Marcus, 2005). Specifically, children who participated in *S.S. GRIN* evidenced higher social acceptance and self-esteem, and lower depression and anxiety relative to the study's control group. Because *Adventures Aboard the S.S. GRIN* enables unlimited exposure and practice opportunity, we expect that the longer term effects of this ITS may be even greater than the in-person program.

5. Conclusion

Developing evidence-based ITSs for SSTs involves the integration of developmental theory, research, computer science, gaming theory, and practical application to improve social programs and interventions for children. The results of this study provide evidence that ITSs can be an effective and welcomed strategy for addressing psychosocial and behavioral issues in the social domain. This methodology has the potential to overcome many of the barriers associated with traditionally-delivered SSTs, and as a result can deliver services much more broadly than existing methodologies. ITSs can be made available to any individual or organization (e.g., educators, parents, mental health providers, youth groups) and can be used in any setting with a computer (e.g., schools, homes, clinics, after-school programs).

Translating evidence-based social skills intervention into ITSs creates the opportunity to provide widespread access to social intervention, and thus close the gap between proven interventions and their widespread use by those most in need. Expanding access to proven programs in this way has important implications for fostering optimal development and promoting positive development for children at risk for poor social, emotional, and academic outcomes.

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