

Improving collaboration skills for children with PDD-NOS through a multi-touch based serious game

Maarten van Veen
Artificial Intelligence
University of Groningen
P.O. Box 407
9700 AK Groningen NL
+31 6 47888486
maarten@mvanveen.nl

Arnout de Vries
Innovation Management
TNO Information and
Communication Technology
P.O. Box 1416
9701 BK Groningen NL
+31 50 58 57778
arnout.devries@tno.nl

Fokie Cnossen
Artificial Intelligence
University of Groningen
P.O. Box 407
9700 AK Groningen NL
+31 50 363 6336
f.cnossen@ai.rug.nl

ABSTRACT

A serious game with multi-touch interaction was developed in order to teach children with PDD-NOS how to collaborate. With the use of multi-touch technology two children can work simultaneously with the same computer and screen. The game consists of six levels with different mathematical problems designed to learn specific basic collaboration skills. The game was tested for four weeks at an elementary school for special education. Because of the limited size of the present study, no firm conclusions can be drawn but teacher ratings showed improvements in children when playing the game, although little structural behavior changes were observed in the classroom. A notable exception was one child diagnosed with autism, who showed significant improvements in all collaboration skills in class. A larger and more long-term study might show that more children accomplish this transfer of skills to the classroom and possibly to other aspects of life as well.

Keywords

Multi-touch, serious game, education, collaboration, autism, PDD-NOS, tabletop, elementary school, children, mathematics.

INTRODUCTION

Educational renewals

In 2005 a set of educational reforms were introduced in the Netherlands under the name “New Learning”. Key to New Learning is that education should enhance insight and understanding. Learning should take place by solving realistic problems within a realistic context. This problem-driven education has students solve problems in project groups with little assistance of a teacher, using peer consulting and collaboration instead.

However, children with an autism spectrum disorder suffer under New Learning. These children have difficulty with

working in groups, collaboration and taking initiative, which are prerequisites to New Learning. As a result, many of these children who formerly went to a regular school, with some extra attention, now have to go to a school for special education because they no longer fit in [2].

The present study aimed at improving collaboration skills in children with an autism spectrum disorder by using a serious game with multi-touch interaction. Before explaining the game and the experimental set up, we will briefly explain about autism and PDD-NOS.

Autism and PDD-NOS

Autism is a neurologic development disorder characterized by problems with interaction, communication and imagination. The consequences are a limited and repetitive pattern of interests and activities. Autism is a heterogeneous disorder with symptoms of varying severity. The term autism spectrum is used emphasizing that symptoms range from singular developmental disorders (or multiple disorders in a very mild form) to very severe (multiple) developmental disorders.

In the middle of the range is a group of disorders without clear borders known as PDD-NOS (Pervasive Developmental Disorder – Not Otherwise Specified). As the last part of the name suggests, PDD-NOS is a leftover group. Children with PDD-NOS do not fully meet the criteria of any of the disorders from the autism spectrum, but they do have problems with social interaction and communication, and have stereotypical behavioural patterns and interests. The social disorder of children with PDD-NOS lies not in the quantity, but in the quality of social interactions. Especially the reciprocity of the interaction is a problem. This disorder is not so severe as to impede social interaction, but severe enough in that these children do not fit in the regular education system.

PREVIOUS WORK

Collaboration

There is a vast amount of literature on social skills intervention. Zaragoza [8] in his review, discussed 27 studies on social skills intervention that focused on teaching isolated skills. While some of these studies

*LEAVE BLANK THE LAST 2.5 cm (1”) OF THE LEFT
COLUMN ON THE FIRST PAGE FOR THE
COPYRIGHT NOTICE.*

showed positive results, they lack the generalization from isolated skills to broader social skills [5]. As collaboration is not an isolated skill but a set of skills this generalization is necessary.

A popular social skills training program used in The Netherlands is “Nietes-Welles” [3]. It is based on Skillstreaming [4] and adapted for children with an autism spectrum disorder. These training programs are however very expensive, require special trainers and are not part of the regular school curriculum.

Serious gaming

Most children find it fun to work with a computer at school. This is even more so for children with PDD-NOS. The computer is a safe place, sheltered from the noise around them and has a predictable setting, interaction and feedback. Working with a computer is very structured; input always has the same output. Furthermore, the delivery of information is mostly visual [1], which is positive for children with PDD-NOS, as they are generally better in understanding visual information.

Michael and Chen [6] give the following definition of a serious game: ‘A serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment’.

A considerable amount of research on serious games has been conducted, both theoretically and practically oriented. Studies on the effectiveness of games as educational tools have consistently found to promote learning and reduce instructional time over multiple disciplines [7]. However, the number of available serious games for education is still limited.

While using a computer, especially in combination with a serious game, can be a strong tool in motivating children with PDD-NOS to learn, it is also an anti-social activity. The child sits alone behind the computer doing his/her task without interaction with other children. However, multi-touch screens might help overcome this problem.

Multi-touch screens

Multi-touch is a technology that has been around for some time but has only recently moved out of the research phase. While multi-touch tabletops are not readily available yet, the body of scientific literature on them is steadily growing.

Touch screens allow for a more natural interaction, in the sense that there is no translation needed from user movement to pointer movement. The user’s finger is essentially the pointer. Multi-touch adds the ability of using multiple fingers and hands and enables natural gestures like rotating and pinching. Inherently multi-touch also implies multi-user interaction as multiple users can use the screen simultaneously, enabling physical collaboration at a computer.

PRESENT STUDY

This study aims at developing a serious game running on a multi-touch tabletop that is affordable and can easily be used by teachers in a school setting. The combination of a serious game with multi-touch technology should allow for an engaging learning experience of collaboration. The goal of the game was to teach children with PDD-NOS to collaborate in pairs with the use of a multi-touch tabletop. In designing the game we involved two game experts in addition to teachers from schools for special education and educational advisors from the Regional Expertise Centrum Northern Netherlands for behavioral problems (RENN4).

Elements of education

In close collaboration with the aforementioned experts the following educational requirements were identified. (i) Most information should be visually presented as children with PDD-NOS are generally of the visual type. (ii) The interface should be simple as the children are easily distracted and confused. (iii) Working towards collaboration should occur in small steps. (iv) Good behavior and accomplishments should be rewarded. (v) The game progress of the players should be comprehensible to the teachers. (vi) The game should feature real educational content from courses such as mathematics, language or history. (vii) The game should have variation in the game play or have multiple levels with different tasks. (viii) The level of difficulty should be adjustable for the game to be challenging to all players. (ix) Learning should take place in the context of the material. (x) The players should be able to compete with one another.

Basis collaboration skills

In close collaboration with the aforementioned experts we identified six basic collaborative skills children with PDD-NOS have problems with. (i) Waiting for their turn, (ii) handling mistakes of the other, (iii) receiving criticism, (iv) sharing tasks and objects, (v) discussing a task with others and (vi) realizing one’s action has implications for the other. This research focused on improving these six basic skills.

GAME DESIGN

The game, called Raketeer, consists of six levels in which the players build a rocket. In these six levels the players have to collect parts for the rocket, collect inventory, mix fuel and defend their rocket to ensure its launch by solving equations. The real goal of each of the levels is to teach the players the six basic skills described earlier and improve their collaboration.

At the start of the game each player chooses a name and a character creating their own virtual identity. The teacher’s rating of arithmetic level determines the level of the equations the players receive. The players are rewarded with math points for correctly solved equations and buddy bonuses for collaborative behavior. Playing games of 4 minutes the players can get a promotion if they have reached enough points. However both players have to be promoted to play the next level.

The goal of level 1 is to introduce the game, get comfortable with the controls and get used to working on the same machine with another player. At level 1 the players each have their own part of the screen and their own equations (fig.1). To enter a solution the players can adjust the green and orange dials by dragging one or more finger(s) over them.

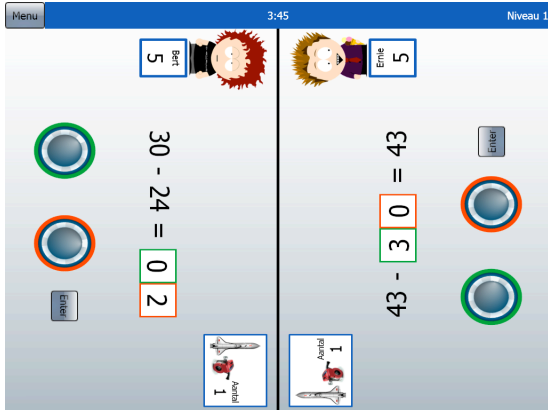


Figure 1. Level 1: Collecting rocket parts.

The goal of level 2 is to work next to each other and start working on the same goal. The players still have their own part of the screen and their own equations, but now collect components for the rocket together.

The goal of level 3 is to teach the players to wait for their turn (fig. 2). The players are presented with a double equation and both have the same four possible answers in front of them. A green square indicates whose turn it is. Answering before your turn results in a negative buddy bonus and waiting for your turn is rewarded with a positive buddy bonus.

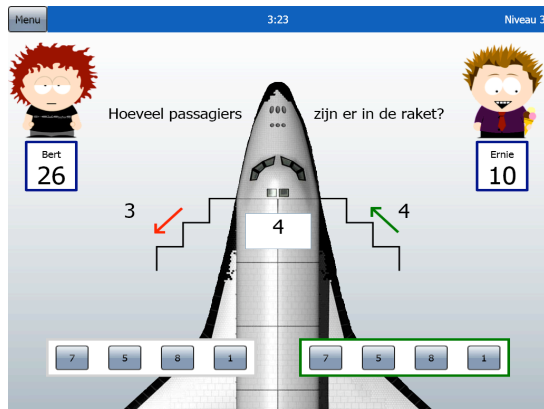


Figure 2. Level 3: Counting passengers.

The goal of level 4 is to share items and to pay attention to the other player's task. The players have to collect items for the first journey. They are randomly assigned four of the ten items. For each correctly solved equation they get an item. Depending on which items they are currently collecting they can keep the item or give it to their buddy by dragging the item accordingly.

The goal of level 5 is to perform a task together while communicating. At the beginning of level 5 the players get to see the finished rocket they build, and have to start mixing fuel (figure 3). Given the answer as well as the operator of the equation, the players have to decide on a solution together (depending on the equation multiple solutions are possible) and turn the dials accordingly to mix the fuel.



Figure 3. Level 5: Mixing fuel.

The goal of level six is to perform two tasks at the same time together, while under pressure. The players have to solve equations to earn shots, which can then be used to shoot down incoming missiles by touching them. When successful, the rocket is launched.

Measurements

Before and after the game was played, the teachers rated the children on their arithmetic abilities and on the six collaborative skills summed up before. The arithmetic abilities were rated on a scale of 6 with 1 being the lowest and 6 being the highest score. The collaborative skills were rated on a scale of 5, with 1 being the lowest and 5 being the highest score. Furthermore the children's behavior during play and in the classroom was evaluated through teacher interviews. During play Raketeer logged data on the children's progress, the equations made and the time played. At every game the experimenter observed the children during play.

PRELIMINARY RESULTS

Raketeer was tested at an elementary school for special education. During 4 weeks, 13 boys and 1 girl, roughly representing the normal population with an autism spectrum disorder, from the age of 8 - 12 played a session of 20 minutes every day.

The subjects each played Raketeer for an average of 2 hours and 35 minutes. Figure 4 shows the subjects game progress in terms of the furthest level they reached.

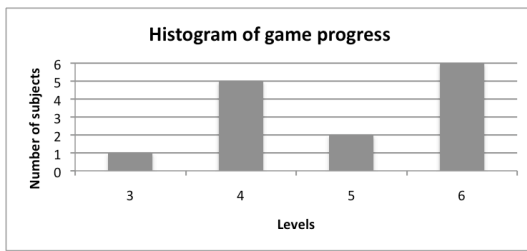


Figure 4. Histogram of the game progress.

As can be seen in figure 4, apart from one subject all have reached level 4, and almost half of the subjects have reached the last level. Only one pair of subjects was able to finish the game during the test phase.

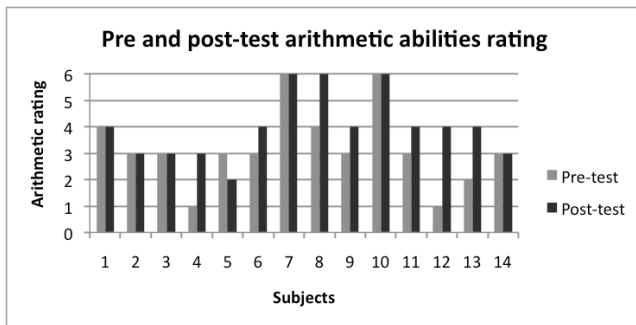


Figure 5. Pre and post test results for the arithmetic abilities ratings.

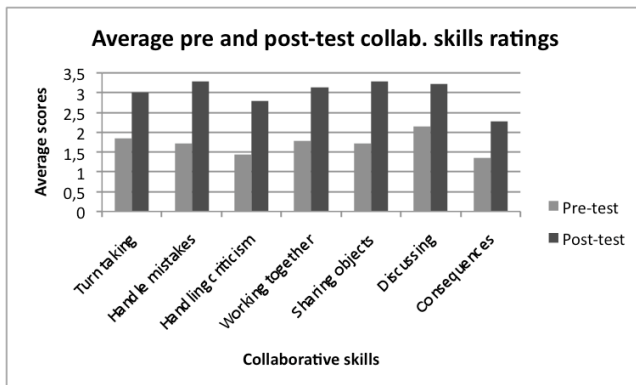


Figure 6. Average pre and post-test results of the collaborative skills ratings.

Figure 5 shows the pre and post-test ratings for the subject's arithmetic abilities. Half of the subjects show the same pre and post-test scores and half of the subject show higher post-test scores. One individual showed a lower post than pre-test score.

Both the average pre and post-test collaborative skills ratings are plotted in figure 6. As can be seen, all collaborative skills show higher average post than pre-test scores, indicating improvement of social behavior in class. However teacher interviews showed only little behavioral transfer to the classroom, apart from one individual. Starting out as the most anti-social subject he is now able to sustain cooperative play.

DISCUSSION

This study set out to explore the possibilities of combining a serious game with multi-touch interaction to teach collaboration for children with PDD-NOS. Results showed some improvement on the arithmetic abilities, but these improvements could be the effect of regular math courses. Results on behavioral change during play are positive, with almost half of the subjects reaching level 6 and teacher interviews indicating improved behavior. Transfer of skills was only partly established as only one individual showed significant improvements of social skills in the classroom. Further analysis of the data should reveal the cause of the contradicting pre and post-test teacher ratings and the teacher interviews.

Whether the approach of using a multi-touch enabled serious game to teach collaborative skills is valuable is not yet clear because of the small sample size of the present study, although preliminary results show at least one success in a severely anti-social boy. A larger study is needed to confirm our preliminary results. Also a longer period of use could improve transfer of knowledge to the classroom and more in general: to real life.

REFERENCES

- Baltussen, M., Clijisen, A., Leenders, Y. *Leerlingen met autisme in de klas*. Drukkerij Giethoorn ten Brink, Meppel, 2003.
- Besseling et al. *Toename gebruik ondersteuning voor jongeren met een gezondheidsbeperking*. Unpublished, 2007. Available at http://www.tno.nl/downloads%5CKvL-APAR-129_2007_3_10949.pdf.
- Emmen, R., Plasmeijer, M. Sociale Vaardigheidstraining van autistische jongeren via de Goldstein groepstherapie. *Engagement*, 18, 6, 1996, 4-8.
- Goldstein, A. P., Sprafkin, R. P., Gershaw, N.J., Klein, P. *Skillstreaming the Adolescent – A Structured Learning Approach to Teaching Prosocial Skills*. Research Press, Champaign, 1980.
- Howlin, P. Practitioner Review: Psychological and Educational Treatments for Autism. *Journal for Child Psychology and Psychiatry and allied disciplines*, 39, 3, 1998, 307-322.
- Michael, D. R., Chen, S. L. *Serious games: games that educate, train and inform*. Thompson Course Technology, Boston, 2006.
- Randel, J. M., Morris, B. A., Wetzel, C. D., Whitehill, B. V. The Effectiveness of Games for Educational Purposes: A Review of Recent Research. *Simulation and Gaming*, 23, 3, 1992, 261-276.
- Zaragoza, N. Vaughan, S., McIntosh, R. Social skills interventions and children with behavior problems: a review. *Behavioral Disorders*, 16, 1991, 260-275.

The columns on the last page should be of equal length.