

Examining engagement and achievement in learners with individual needs through robotic-based teaching sessions

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Abstract

Research suggests that robotics can provide an engaging learning experience for learners with special educational needs. However, further work is required to explore the impact of robots within the classroom, particularly for learners with intellectual disabilities (ID). This paper seeks to further explore the potential effects of robots on such learners through examining engagement and goal achievement within teaching sessions. Eleven participants with ID were recruited from two countries to take part in the study using an ABAB design where the participants acted as their own controls. An appropriate learning goal for each participant was selected by the teacher and equivalent control sessions designed seeking to achieve the same learning goal but without the robot. Engagement, using eye-gaze, learning goal achievement with and without help and goals not achieved provided the outcome measures from the sessions. This study found no significant difference between the robot and the control sessions for any of the outcome measures utilized suggesting robots are as effective as teaching tools as traditional methods. Through an increased sample size and a rigorously applied experimental protocol, this study provides new data and methodological considerations for further work based on the techniques applied in this study.

Introduction

The potential benefits of robots within education are well explored in the current literature. They have the power to be engaging, motivating and to encourage creative thinking especially in children (Benitti, 2012). Furthermore, robots can offer a unique avenue to engage students with special education needs (SEN) who typically have problems with mainstream education. Children with autism, for example, may have issues maintaining eye contact or emotionally engaging

Practitioner Notes

What we already know about this topic

- Robots can encourage engagement in the learning process for students with intellectual disabilities.
- There is a lack of work examining the potential use of robots within formal learning.
- There is a lack of work utilizing experimental protocols to study the use of robots.

What this paper adds

- Knowledge of the impact of robots on learner engagement using eye-gaze as an outcome measure.
- Knowledge of the impact of robots on goal achievement in pursuit of structured learning objectives.
- Knowledge of the experimental protocol and suggestions for refinement of the outcome measures in future trials.

Implications for practice and/or policy

- Robots can be as effective as traditional teaching methods in promoting engagement in learning for students with intellectual disabilities.
- Robots can be as effective as traditional teaching methods in the pursuit of learning goals for students with intellectual disabilities.
- The effect of robots on learning appears to be variable depending on individual learner characteristics.

with a teacher or their peers. In such cases, an anthropomorphic robot can provide a point of interaction for social skills development that may be transferable to the real world (Owens *et al.*, 2008) in the long term. Indeed, work has shown that interaction with a robot over a short period (five sessions) can reduce “stereotypical autistic behaviour” (Werry & Dautenhahn, 1999) when interacting with the device in a free-play session under the supervision of a teacher. In particular, instances of eye contact and attention focus, which are the features autistic children lacked, were noted as “substantial.”

The use of robots within SEN teaching is gaining increased attention within research due to their ability to engage students in social activities. Anthropomorphic robots, for example, have been proposed as ideal social mediators encouraging engagement within student groups that find social skills difficult to develop, and by extension find traditional learning methods difficult (Dautenhahn & Billard, 2002; Ferrari *et al.*, 2009; Scassellati *et al.*, 2012; Standen *et al.*, 2014).

Furthermore, studies within the area have begun to show a positive impact that robots could have within teaching through encouraging engagement with learning activities. A study using the NAO robot demonstrated an increased level of engagement over the course of several teacher-student sessions (Hedgecock, 2014); however, engagement within this study relied on teacher ratings and lacked an effective control. A single case study with 3 participants over 12–14 “play sessions” found that instances of play increased over time (Klein *et al.*, 2011). The idea of play is important in such studies as it encourages engagement and is a fundamental part of acquiring social skills in early life, something which SEN learners may struggle with. Indeed, engagement has been described as the single best predictor of learning (Iovannone *et al.*, 2003), hence its presence as an outcome measure in a number of studies. Robots have also been used to encourage imitation behavior in children with autism where the robot acted as a social mediator (Werry &

Dautenhahn, 1999); as mentioned earlier, interacting with human peers may be difficult for this target group which can impact on imitation behavior (a key tool in social development).

Further work suggests that the use of anthropomorphic robots, such as the NAO, can enable the study of proprioceptive cues in learners with autism spectrum disorder (ASD) due to their ability to mimic full body cues (Chevalier *et al.*, 2016). Anthropomorphic robots have also been utilized in conjunction with Applied Behavioral Analysis (ABA) (Salvador *et al.*, 2016), a technique sometimes included in therapy for people with autism due to its focus on positive behavior outcomes.

Work is not only limited to anthropomorphic robots however. Research using Lego Mindstorms robots seemed to produce more collaborative and social behavior among the participants in a study when qualitatively observed (Kärnä-Lin *et al.*, 2006). Similar findings were displayed when using the Lego Mindstorms NXT robot in a more longitudinal study aimed at children with high functioning autism (Wainer *et al.*, 2010). Furthermore, initial findings from Aslam *et al.* (2016) found evidence that non-humanoid robots were more engaging than their anthropomorphic counterparts. The authors suggest that this may be due to the age range and the ability of the sampled participants, with older, more able students preferring the non-humanoid device; however, further work is required to verify this assertion.

A class of special education students will present with an extremely wide variety of learning needs. Robots would appear to be well suited to such potential variability due to their multi-modal interfaces (Robins *et al.*, 2005) and their ability to perform in the role of a tutor, tool or peer (Mubin *et al.*, 2013). There remains, therefore, a need to further explore the potential impact of robots in pursuit of tailored learning goals. Diehl *et al.* (2012) suggested work must be done to determine the incremental validity of these interventions to further support their long-term use in teaching for students with ASD and therefore, learners with ID.

Impact of cultural diversity

In addition to the previous considerations, one aspect that might influence the effectiveness of robotic interventions is related to the context in which such interventions are delivered. Evidence in clinical literature extensively documents, in particular, that to understand the outcome of any treatment targeting children with special needs, considering cultural variations across intervention settings is as important as the inter-individual variation within the clinical sample (Tincani *et al.*, 2009). Libin and Libin (2004), for instance, involved Americans and Japanese in an interactive robot therapy session using the robot cat called NeCoRo. The results showed that Americans enjoyed touching the robotic cat more than the Japanese who demonstrated more annoyance when the cat looked directly at the interlocutor's eyes. More recently, Rudovic *et al.* (2017) explored behavioral engagement of children with autism from two culturally diverse groups (Japan and Serbia) in the context of occupational therapy assisted with a humanoid robot. Statistically significant differences in engagement displays in the two groups were found suggesting interaction patterns may be influenced by cultural factors.

Cultural differences, however, may also affect the attitudes of the professionals who may be involved in robot-based intervention scenarios. In general, research indicates that people with different nationalities tend to rate differently their experiences with robots on usefulness, enjoyment, sociability, anthropomorphism and perceived behavioral control (Conti *et al.*, 2017; Li *et al.*, 2010). Specifically, Conti *et al.* (2015) examined the willingness to use robotic interventions among psychology students from Italian and British backgrounds. The findings suggest general positive attitudes among all participants toward robotic interventions. However, the differences were observed in the approach to use where Italians appeared more likely to have a positive intention to implement the technology (Conti *et al.*, 2015).

Taken together, these studies highlight the possible influence of different cultural backgrounds of both target users and educational professionals on person-robot interaction patterns and robot use. Research shows that the success of technology use in the educational settings largely depends on the trainers' attitudes toward technology use (eg, Albrini, 2006). Attitudes are considered as a major predictor of adoption of new technologies in the educational settings. Thus, in the present study, we assumed that the trainers' attitudes toward robot-based interventions can play an important role in the acceptance and future use of such devices in educational activities and may vary according to cultural influences.

Research aims

This paper aims to build on such work and explores the impact of robots on learners with ID when used in pursuit of individually tailored learning goals. The results are presented from an experiment that utilizes a control condition and conducted across two countries. In detail, this study aims to explore the effect of:

- 1 Robots on engagement when utilizing clearly defined learning objectives and using comparative controls.
- 2 Robots on learning goal achievement.

This study differs from others in its use of a single subject design methodology utilizing a more appropriate control condition. Further difference is found in the use of clear and structured learning outcomes within the trial sessions.

This work formed a part of the Edurob project (2016), which was funded with support from the European Commission (Lifelong Learning Programme of the European Union). The project sought to design and implement a robot-based pedagogy to improve the cognitive development of students with SEN. This paper reports on the trials that took place in the UK and Italy.

Methods

Study design

A series of case studies following an ABAB single subject design where participants engaged in a series of control sessions followed by sessions with the robot were conducted; within this design, performance within the control sessions (A) is compared to the intervention sessions (B) allowing participants to provide their own control for comparison. Individual learning goals were allocated to each participant; these learning outcomes and session outlines were developed in conjunction with teachers. In the control sessions, the teacher assisted the participant to achieve the same learning goals as they had during the robot sessions. Sessions were video recorded for subsequent analysis of the duration of engagement within them and the frequency of goals achieved.

Setting

The participants were recruited from one school within the UK for children with severe and profound and multiple disabilities, and dedicated therapy centers in Italy specializing in the teaching and learning of students with ID and autism. These two sites were included due to their participation in the EduRob project, and as they provided participants that met the target profile required by the project. The study design allows for the heterogeneous nature of the target population across these two sites as each participant serves as their own control.

Participants

Teachers from the centers selected participants they thought would be the most suitable to take part in the trial based on their individual needs and learning outcomes. In order to obtain an estimate of their degree of intellectual disability, teachers completed the Short Form Adaptive Behaviour Scale (SABS) (Hatton *et al.*, 2001), a 24-item short form of the 73-item Adaptive Behavior Scale—Residential and Community (Part 1; Nihira, Leland, & Lambert, 1993) which can be transformed into an IQ equivalent. In total, 11 participants were recruited for this paper (8 from the UK and 3 from Italy) Table 1 summarizes the characteristics of the participants. The IQ equivalents are an overestimate as the participants from the UK were all from a school for young people with severe to profound ID. However, these estimates give a picture of the variation between the participants in terms of their ability. More detailed descriptions of their additional problems are also given in Table 1.

Intervention

The trial utilized the NAO NextGen humanoid robot developed by Aldebaran robotics. This robot was selected due its use in related studies and the wide range of available behaviors/interactions it can provide. Interactions were programmed using the Choregraphe software, a software package provided by the manufacturers for working with the NAO. Initially, the trial implemented control over these behaviors with a custom-built mobile application that sought to provide a

Table 1: Participant overview

Participant	Gender	Age	Disability and effects	IQ
001	M	15	Down's syndrome Permanent hearing loss	60
002	F	8	Moderate bilateral hearing loss Auditory neuropathy Moderate global developmental delay	63
003	M	9	Down's syndrome	60
004	M	10	Sensory neural hearing loss Congenital hypothyroidism Epilepsy	64
005	M	11	Myoclonic atstatic epilepsy Developmental delay	69
006	M	10	Mild global developmental delay PTCD Severe/profound hearing loss Auditory neuropathy Reduced vision in left eye	61
007	M	8	Developmental delay Generalized hypotonia	61
008	M	15	Moderate global developmental delay	59
009	M	4	Autism spectrum disorder	<60
010	M	4	Autism spectrum disorder	66
011	M	4	Autism spectrum disorder	66

user-friendly method of firing behaviors quickly in response to participant behavior within the session. However, due to reliability issues, full control of the robot changed to rely solely on Choregraphe running on a laptop connecting to the robot over its Wi-Fi Hotspot.

Outcome measures

Related studies have used a variety of methods to determine engagement in learners with ID; Hedgecock *et al.* (2014) asked teachers to complete the Special Schools and Academies Trust Engagement Scale <http://www.ssatuk.co.uk> based on the preexisting knowledge of the learner. Because the subjectivity of such ratings may introduce bias to the data collection process, this study utilized eye-gaze as a measure of engagement whereby if the participants' focus was on the learning materials, the robot, or the teacher they were said to be engaged. The use of eye-gaze for measuring engagement is consistent with other studies in the field (Bal *et al.*, 2010; Nakano & Ishii, 2010); for example, Justice *et al.* (2005) utilized such an approach to examine preschoolers' attention in reading exercises.

Achievement scores were also measured to assess any direct effect upon the participant's learning. The number of times a participant achieved a goal within the task without help, with help or failed to achieve a goal at all was counted. These were then converted to percentage achieved without help, percentage achieved with help and percentage not achieved.

Procedure

At the Italian trial site, an educator from the local Public Health Trust with more than six years of experience with ASD and who attended a one-day course on the use of the NAO robot selected the participants and ran intervention sessions alongside a trained researcher. At the UK site, after a demonstration of the robot and its capabilities, the teachers selected appropriate participants. The UK sessions were also run by a trained researcher in conjunction with a teaching assistant (leading the session) who was responsible for the day-to-day care of the participants. They were responsible for delivering the session and determining when to bring the session to a close. The project was ethically approved, and parental consent was obtained for each participant. Following individual meetings with each teacher, appropriate learning objectives were identified for each participant. From these learning objectives, the session activities were designed including equivalent controls that sought to achieve the same learning outcome. An overview of these objectives and sessions is provided in Table 2.

A summary of the participants and their learning goals is presented in Table 3.

Each learning scenario provided scaled learning, so the complexity could be adjusted if required if the participant either was not responding or found the activity too easy. Control sessions were run in an identical manner as the intervention differing only in the absence of the robot.

Interestingly, many of the learning objectives chosen involved navigation around a maze. This was chosen due to the ease with which the problem could be scaled depending on the difficulty; that is, by increasing the complexity of the maze and the number of steps required to solve it. Furthermore, the activity is easily replicated as a control with the researcher or toy taking the place of the robot.

For a number of learning objectives, communication was achieved using flash cards depicting arrows allowing participants to string together sequences to achieve the learning goals outlined.

A timetable was devised with teachers for running the sessions over an 8-week period consisting of at least one control and intervention session each week with each participant; days and times were varied to account for any possible variability in performance. However, due to the

Table 2: Sessions overview

<i>Learning objective</i>	<i>Robotic scenario</i>	<i>Control scenario</i>
Simple imitation	The robot performed one action/sound for the participant to copy	Human actor performs actions for the participant to copy
Sequence imitation	The robot performed a sequence of actions to be copied	Human actor performs a sequence of actions for the participant to copy
Respond to simple instruction	From a set of cards, the robot made a request to select one using either sounds (eg. animals) or commands	Request made by actor, sounds (when needed) played through tablet device
Recognize images and symbols	Robot asked, "Which one is the...?" and told to choose which was the correct animal picture card in front of her. Robot played reward when successful	Actor asked, "Which one is the...?" and told to choose which was the correct animal picture card in front of her. Suitable reward equivalent provided
Understand and communicate directions	Participants were asked to direct the robot through the maze vocally or using arrow cards if needed	Participants asked to direct a toy or other object through a maze vocally or using arrow cards if need
Initiate communication	Participants were asked to produce a verbal request to initiate a robotic action	Participants were asked to produce a verbal request to initiate a actor action
Vocal imitation	Participants were asked to repeat word or vocalizations uttered by the robot	Participants were asked to repeat word or vocalizations uttered by the actor
React to name	Participants were called by their names by the robot and were expected to direct their attention to the interlocutor	Participants were called by their names by the actor and were expected to direct their attention to the interlocutor
Object naming	Participants were requested by the robot to name the image showed on a card	Request made by human actor

Table 3: Participants' learning objectives

<i>Participant</i>	<i>Learning objectives</i>
001	Simple imitation Imitation of sequences Respond to simple instruction
002	Recognize images/symbols Respond to simple instruction Understand and communicate directions
003, 004, 005, 006, 007, 008 009	Understand and communicate directions Initiate communication Simple imitation Vocal imitation
010	Initiate communication React to name Respond to simple instruction
011	Initiate communication React to name Respond to simple instruction Object naming

unforeseen illnesses and the variability in the mood of the participants due to the target groups' profile, some participants were unable to complete many sessions giving a range of 3–10 robot sessions and 2–6 control sessions. Each session was up to 10 minutes in length; the exact session length varied depending on the participant. Each session was digitally recorded using a video camera that was small and discrete, placed in a strategic but not immediately noticeable area of the room to avoid camera consciousness (Shrum *et al.*, 2005).

Data recorded from all sessions were analyzed using the ObanSys video coding application for iOS devices <https://www.mangold-international.com/en/products/software/mobile-observation-with-obansys>. The participants were assessed for engagement based on eye-gaze directed toward the object of learning as a proportion of session length and for goals achieved, goals achieved with assistance (where any intervention from the teacher or researcher was required to achieve the goal) and goals not achieved when attempted. The duration of engagement was presented as a percentage to take into account variation in the session length and goal achievement was converted to a percentage of tasks presented as the number of tasks that could vary from session to session. Video analysis was repeated for a number of sessions to ensure rater reliability; no significant difference was found between the sessions subjected to repeat analysis suggesting the rater was reliable when analyzing the videos.

At the end of the whole sessions, all the educators/trainers involved in the interventions were asked to report their attitudes toward the robot used in their practice using a modified version of the Assistive Technology Device Predisposition Assessment (ATD-PA). The original version of the ATDP-A is a 12-item questionnaire asking respondents to rate their predisposition to the use of any type of assistive device (Scherer & Craddock, 2002). The modified version (see Appendix) is shorter than the original version and addresses seven dimensions which are assumed to form the

user attitude toward a technology: goals, effectiveness, understanding, safety, ease-of-use, support, and transferability. Each dimension was rated on a 5-point Likert scale (1 (No) to 5(Yes)), with lower scores indicating more negative attitude, and a score equal to 3 (Possibly) considered as a threshold, below which the scores should be considered as an indicator of a negative attitude.

Data analysis

Data were analyzed using the statistical software package SPSS 20. The mean of engagement and achievement scores was calculated for each participant in each condition. Data were not skewed and a Levene's test for homogeneity of variance demonstrated that the variance between the two conditions for each outcome measure was not significantly different. Therefore, a one-tailed paired sample *t* test was used to compare the means of all the measures using a significance level of $P < 0.05$. Item-by-item analyses were conducted for the debriefing session questionnaires. All data are expressed as means (*m*) and standard deviations (SD).

Results

Engagement

The means for each participant in each condition are shown in Figure 1. For the group as a whole, the mean duration of engagement in the robot sessions (85.3, 19.2) was higher than in the control sessions (79.8, 26.5). However, this difference did not reach significance ($t = 1.532$, $df = 10$, $p = 0.078$).

Goal achievement

The mean percentage of goals achieved for each participant in each condition is presented in Figure 2. For the group as a whole, the mean percentage of goals achieved in the robot sessions (48.9, 22.1) was higher than in the control sessions (47.2, 23.1) but this difference did not reach significance ($t = 1.542$, $df = 10$, $P = 0.077$).

Similarly, there was no significant difference observed for goals achieved with assistance ($t = -0.133$, $df = 10$, $P = 0.448$). Within the robot and control sessions, the means and standard deviations were 26.1%, 18.5% and 26.7%, 18.2, respectively. Means for each individual participant in each condition are provided in Figure 3.

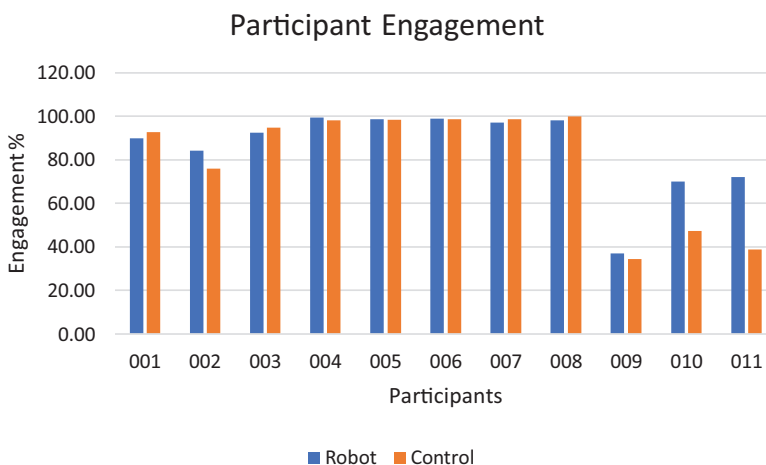


Figure 1: Participant engagement overview

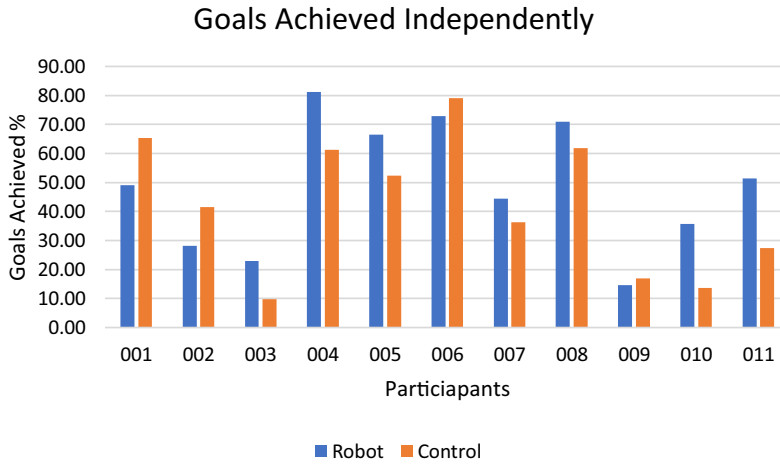


Figure 2: Goals achieved overview

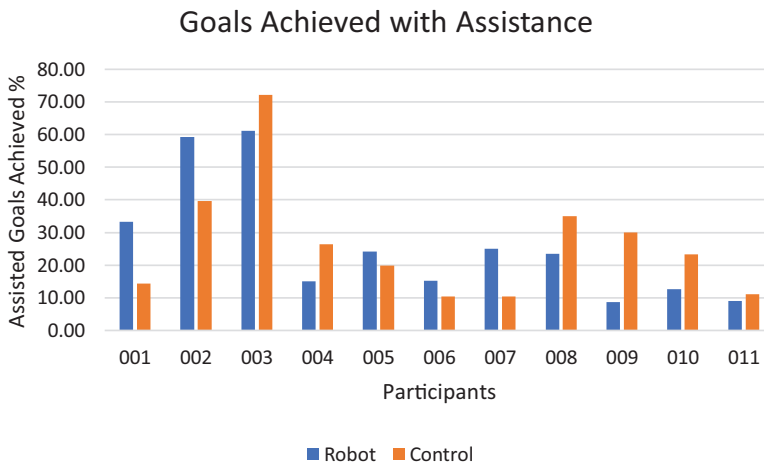


Figure 3: Goals achieved with assistance overview

Finally, Figure 4 provides the means of goals not achieved for each participant from the two conditions.

Although the mean percentage of goals not achieved was higher in the robot condition (28.1, 21.2) than in the control condition (25.1, 22.7), this difference did not reach significance ($t = -0.740, df = 10, P = 0.238$).

Trainers' attitudes

From the assessment of the trainers' ($N = 6$) attitudes toward the employment of the robot in educational interventions, an overall positive response emerged from the UK ($M = 3.5, SD = 0.6$) sample, while the Italian sample rated the device quite below the satisfactory level ($M = 2.9, SD = 0.7$). Item-by-item analysis (Figure 5) clearly highlights the dimensions that produced such discrepancy between the UK and Italian scores. While the UK trainers seemed to be quite satisfied in each dimension, the Italian ratings fell below the satisfactory level for the items:

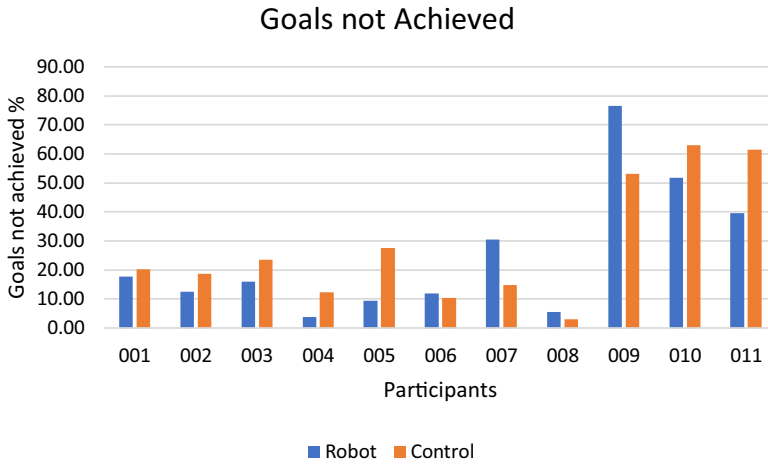


Figure 4: Goals not achieved overview

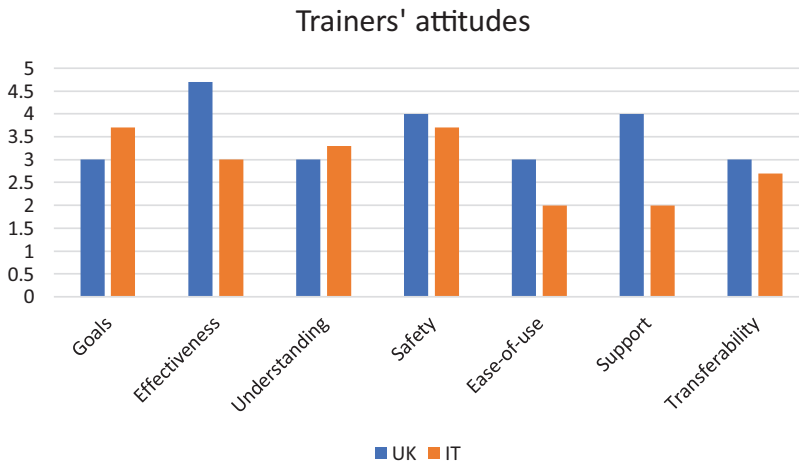


Figure 5: Trainers' attitudes toward the robot-based intervention in the UK (n = 3 and Italy (n = 3)

ease-of-use and support. To note, in addition, a marked discrepancy was observed between the two samples in the scores belonging to the item effectiveness, in which the Italian trainers were more negative compared to their UK colleagues.

Discussion and further work

Unlike previous studies using a robot in special education, group results in this controlled study did not indicate that working with the robot had a significant effect on engagement or goal achievement. Engagement and the percentage of goals achieved independently were higher in the robot sessions, but the difference did not reach significance. Group analysis does mask individual difference and the examination of individual scores indicates that for some participants the levels of engagement and goals achieved independently were higher with the robot. This would suggest that, due to the heterogeneous nature of the target population, the intervention

may be more effective for some students and should be considered on a case-by-case basis for teaching implementation where appropriate.

One explanation for why more widespread increases were not seen with the robot in this study may have been the nature of the control condition. The use of carefully selected, tailored and structured learning goals and learning scenarios may therefore be key to providing engagement for learners with ID. This, combined with a clear role for the teaching assistant within both the control and intervention sessions, has appeared to aid engagement. Indeed, within the scenarios directing either the robot or the researcher around a maze, the participants appeared to take as much enjoyment in either condition. It is also possible here that a ceiling was hit for engagement which would be difficult to increase any further.

The duration of eye gaze as a proxy for engagement had high reliability but its validity has not been established. In a previous study, (Hedgecock *et al.*, 2014) used the SSAT engagement scale, a teacher-completed rating scale. This is a more global measure asking about engagement in general rather than in a specific teaching or learning situation and is open to bias when teachers cannot remain blind to the experimental condition of the participant. Discussing main stream school students, Skinner *et al.* (2008) include attention as one of the indicators of classroom engagement. The use of eye-gaze is an attempt to capture that in specific learning situations, although this may be more problematic with participants with autistic tendencies who do not use eye contact in the same way as others do. Sessions utilizing the maze learning activity tended to take up all available space in the room and as such, it would be difficult for the participants to not maintain their focus of attention on the learning material.

While goal achievement is a straightforward and reliable outcome measure, it is also only a frequency measure without capturing the quality of achievement. It is also only capturing short-term effects when some participants with ID may need longer exposure and longer term effects may be seen outside the learning situation. Teaching assistants present within the sessions commented on this. Of one the participant with very low levels of communication skills who relied on simple sign language to communicate, his teaching assistant reported a marked improvement in this ability: "this is the best I've ever seen [participant] sign. Usually he just signs his name or to say yes or no...". Similarly, participant 007 began the sessions utilizing signs but soon moved onto using vocal commands instead, an outcome that surprised the teaching assistant. Further work is required to identify appropriate measures to determine if the introduction of the robotic teaching methods can explain observations such as this.

While the study employed a control condition, there are limitations that need to be considered with the use of the experimental design employed. The heterogeneity of the participants in terms of abilities, learning needs and learning goals makes a between subjects design impractical. However, any within subjects design then has the challenge of handling an order effect. The ABAB design minimizes the effect of changes over time by including two exposures to each condition. Thus, there are transitions from both A to B and B to A and the duration of exposure is kept equal. These two characteristics help minimize the possible distorting effect of different activities taking part in subsequent sessions as participants progress through new learning activities. Unfortunately, the time-consuming nature of this type of design inevitably limits the number of participants a research team has the time and resources to include. While the statistical test used in this study did not violate any assumptions, analyzing such a small sample risks a Type II error.

From the results of the teachers' questionnaire, two considerations should be made. First, the perception of the robotic platform is relatively positive in terms of effectiveness in helping professionals achieving the students' goals. However, the robotic platform may suit some learners more

than others and further work is required to determine individual learner characteristics and the associated effect of the robotic intervention. Secondly, technological competence and lack of continuous support (as measured respectively by the items related to ease-of-use and support) may make the use of the robotic platform difficult, increasing the likelihood that the robot will not be used in the future by potential stakeholders. Assuring either remote or onsite support may increase the likelihood that early adopters keep using the device. Further, training courses should provide at least basic indications on how professionals may face robots' breakdowns and malfunctions. While this study utilized two separate sites in two countries, further work is required to examine the impact of cultural diversity on the uptake of robotic learning tools. Although some difference in trainer attitude is apparent from Figure 5, conclusions are limited by the sample size and the scope of this study.

Concluding points

- Educational robots have aroused much interest and early studies reported significant benefits. However, researchers must ensure that the studies take account of other contaminating factors when evaluating the impact of new technology. The use of carefully selected, tailored and structured learning goals and learning scenarios may be just as important for learners with ID.
- Group analysis does mask individual difference and the examination of individual performance indicates that the intervention may be more effective for some students than others. In order to assist teachers in deciding whether this approach would help their students, further studies should consider the use of a more detailed analysis of the videos than that performed here. This might help identify which students benefit and perhaps which learning activities are better suited to this intervention.

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Statements on open data, ethics and conflict of interest

- a Requests for data may be made to the corresponding author.
- b This project was conducted with full ethical approval from Nottingham Trent University and the University of Nottingham.
- c The authors do not report any conflicts of interest.

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APPENDIX

Modified version of the Assistive Technology Device Predisposition Assessment (ATD PA). The tool is illustrated in the table below. It asks the respondents to rate their predisposition to using the specific assistive technology (robotic device) under consideration.

<i>Questionnaire to be completed by stakeholders involved in the EDUROB project</i>	<i>No</i>	<i>Possibly</i>	<i>Yes</i>	
Does the child/adult you work with have goals that you judge will be better or more easily achieved by using the robotic device rather than alternative to its use?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Do you think that the child/adult you work with could increase his/her learning achievement by using the robotic device?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Do you know how to use the robotic device and its various features?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Will the child/adult feel physically, emotionally, and socially secure when using the robotic device?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Is the robotic device usable with little or no discomfort, stress and fatigue?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Do the supports, assistance, and accommodations exist for successful use of this device?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Will the device fit in all relevant environments? (eg. school, clinics,...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Completed by				

Other info