

Table 1 – Characteristics of teachers

<u>Participant Number</u>	<u>Gender</u>	<u>Age</u>	<u>Position held within school</u>	<u>Age range of pupils taught</u>	<u>No. years experience in special Education</u>
002	Male	32	Music Teacher	3-19	3
003	Female	39	Teacher	8-11	12
005	Female	31	Teacher, Temporary ICT co-ordinator	11-14	4
006	Male	51	Teacher	7-12	1
007	Male	28	Teacher	17-19	2

Table 2 Characteristics of pupils

<u>Pupil</u>	<u>Gender</u>	<u>Age</u>	<u>Summary of disabilities</u>	<u>Effect of disabilities</u>	<u>Attainment levels</u>
KW	Male	12	<ul style="list-style-type: none"> • General developmental delay • Severe learning and communication difficulties 	<ul style="list-style-type: none"> • Short attention span and easily distracted • Communicates mainly through body language, although knows some signs and symbols 	English: P6.6 to P7.6 Maths: P6.8 to 1C.2
SH	Male	10	<ul style="list-style-type: none"> • Dystonic Cerebral Palsy • Epilepsy (poorly controlled) 	<ul style="list-style-type: none"> • General increased tone, affecting posture and movement • Frequent seizures • Lack of communication skills 	English: P3.4 to P4.6 Maths: 2.8
ST	Female	11	<ul style="list-style-type: none"> • Cerebral palsy • General developmental delay • Visual impairment 	<ul style="list-style-type: none"> • Limited visual field • Better vision in left eye than right eye • General low muscle tone • Very limited vocal skills 	English: P3.4 to P3.6 Maths: P3.8
TH	Male	17	<ul style="list-style-type: none"> • Significant developmental delay • Autistic Spectrum Disorder • Epilepsy 	<ul style="list-style-type: none"> • Delayed communication and interaction skills • Lack of independence • Social difficulties • Poor focus & short attention span • Difficulty understanding abstract concepts 	English: P8.8 to 1C.8 Maths: P7.8 to P8.8
TN	Male	9	<ul style="list-style-type: none"> • Global developmental delay • Cerebral atrophy • Epilepsy • Microcephaly 	<ul style="list-style-type: none"> • Severe learning disabilities (SLD). • Short attention span • Reduced vision 	English: P3 to P3.2i Maths: P3.4
PF	Female	13	<ul style="list-style-type: none"> • Mild cerebral palsy • Severe learning difficulties • Autistic Spectrum Disorder (ASD) 	<ul style="list-style-type: none"> • Non-verbal, relying on gesture and body language • Dislikes loud/sudden noises 	English: P3.6 to P4.6 Maths: P4 to P4.6

Table 3 – The plans for the case study sessions with each pupil, and the modifications made to each session.

<u>Pupil</u>	<u>Learning Objective</u>	<u>Original plan for session</u>	<u>Changes made</u>
KW	To use symbols to build sequences of up to 4 events, and recognise they have an order.	<p>Input: Flashcards</p> <p>Objectives:</p> <ul style="list-style-type: none"> To learn the meaning of the symbols through interaction with the robot. To recognise that there must be an order to some actions (e.g. the robot cannot dance when sitting down) To put together sequences of up to 4 events <p>Design of sessions</p> <p>The session had already been tested with KW in the pilot study, with the session and format outlined above.</p>	<ul style="list-style-type: none"> Addition of verbal feedback from the robot (e.g. “I can’t walk when I’m sitting down. I need to stand up first”.)
SH	To learn to recognise numbers up to ten and encourage choice making.	<p>Input: Switches</p> <p>Objectives:</p> <ul style="list-style-type: none"> To choose a preferred action to be performed by the robot from a choice of two To identify numerals up to ten, and choose the correct one using a switch <p>Design of sessions</p> <p>To present SH with two switches, each with an associated number, with the robot asking him to identify a number. The pupil would then make his choice, and be given feedback by the robot. If wrong, he would be prompted to try again; if correct the robot would say “well done” and walk forwards a number of steps corresponding to the selected number towards a “finish line”. Once at the finish line, the robot would play a song or dance.</p>	<ul style="list-style-type: none"> Initially, the pupil had some trouble pressing the switches, so from session 3 the switches were both put onto switch mounts, which seemed to help. Pupil appeared to prefer the robot to dance than to play a song, therefore dancing was selected as the reward.
ST	To gain an appreciation of	<p>Input: Switches</p> <p>Objectives:</p>	<ul style="list-style-type: none"> In the first session, the pupil simply did not respond very well to the objectives set. This is

	cause and effect	<ul style="list-style-type: none"> To trigger a preferred stimulus from a choice of switches <p>Design of sessions</p> <p>To present the pupil with a choice of 2 switches, with each triggering a different stimulus. By pressing the switch, it was hoped that the pupil would learn that one switch (with a particular symbol or colour) would trigger a stimulus she preferred to the other. The pupil would then, hopefully, be able to consistently choose the switch triggering the stimulus she preferred, even when the switches were moved around, for example. This would help the pupil understand the principle of cause and effect.</p>	<p>possibly due her impaired vision, which made it difficult to see the robot and the switch.</p> <ul style="list-style-type: none"> After a rethink with the teacher, a more appropriate learning objective of “to encourage vocalisation by repeating what the robot says” was set. The pupil’s vocabulary was limited, so only words and utterances from the pupil’s vocabulary were used Audio recordings of the pupil saying the words were used, as the robot has the function to play mp3 and wav sound files. A “game” of repeating to one another could then be played.
TH	To improve the pupils sense of direction by learning the concepts of “forwards”, “backwards”, “left” and “right”	<p>Input: Smartphone (Samsung Galaxy Note II)</p> <p>Objectives:</p> <ul style="list-style-type: none"> To correctly steer the robot from a start point to an end point using the Smartphone’s accelerometer as a steering wheel (using an app for the phone, and a server for the computer, available from (Robot App Store, 2012) To correctly answer questions about the direction travelled <p>Design of sessions</p> <p>The robot was placed on a blue cross, and the pupil was asked to make the robot move to a red cross. He was then questioned whether the robot was moving forwards, backwards, left or right. It was hoped that by having the robot demonstrate these abstract concepts, it would help him learn.</p>	<ul style="list-style-type: none"> The pupil found the staff member to be more distracting than helpful, therefore after the first session the pupil and researcher worked together without additional staff members The pupil struggled to hold and use the phone in the first session. As a result, the phone was attached to a plastic steering wheel to make it simpler for the pupil. The pupil struggled to grasp the concepts of direction, so the starting cross had “forwards”, “backwards”, “left” and “right” written on, and the robot had post-it notes with “left” and “right” stuck to each shoulder to help give the pupil a reference for his directions. It was hoped these could be removed as his skills progressed; although this was not the case by the fifth session, he did seem to be showing improvement.
TN	To understand that his actions can have an	<p>Input: Sound recognition</p> <p>Objectives:</p> <ul style="list-style-type: none"> To deliberately trigger the robot to perform a desired 	<ul style="list-style-type: none"> It was found that giving the pupil an implement to make a noise with, such as a drum, was too distracting, thus clapping and stamping were used

	effect from a distance	<p>behaviour</p> <ul style="list-style-type: none"> To refrain from attempting to re-trigger the robot until it has finished the behaviour. <p>Design of sessions</p> <p>The sound recognition on the robot was used to recognise when the pupil made a noise (e.g. clapped, stamped feet). When a noise was recognised, the robot would perform an action, such as dancing, or waving and saying “hello”.</p>	<p>to trigger the robot.</p> <ul style="list-style-type: none"> In the first session, the pupil was shown a number of actions. It seemed that his favourite was a short dance to the song “Gangnam Style” (produced by (Arcambal, 2012) and freely available for download), therefore this was chosen as the action as it appeared to be most motivational.
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Table 4 Engagement scale scores for all pupils

<u>Pupil</u>	<u>Engagement Scale Score</u> <u>(in class)</u>	<u>Engagement Scale Score</u> <u>(in session 5)</u>
KW	7	25
SH	11	22
ST	11	12.5
TH	17	21
TN	4	25
Median (IQR)	11 (5.5-14.0)	22 (16.75-25.0)