Educational Robotics for People with Learning Disabilities

EduRob

Lifelong Learning Programme

Technical Requirements

Report from stakeholder qualitative survey

EDUROB: Educational Robotics for Students with Learning Disabilities (EDUROB - 543577-LLP-1-2013-1-UK-KA3-KA3MP)

Deliverable	D2.3
Work Package Title	Research and Analyse
Author(s)	Joanna Kossewska (UP)
Status	Live Document
File Name	Report D2.3. technical requirements15.06.docx

The EDUROB (543577-LLP-1-2013-1-UK-KA3-KA3MP) project has been partially funded under the Lifelong Learning programme. This publication reflects the views only of the author(s), and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Contents:

1. Introduction

The literature review leads to the main conclusion that using robots may support disable individuals development. Robins and colleagues (Robins et al., 2012) showed that educational robotics have an enormous potential as a learning tool, including supporting the teaching of subjects. However the procedure and technical aspects of robot mediated learning as well as support development might differ.

The effectiveness of robot mediated trainings of stimulating different social and cognitive skills (theory of mind, emotion recognition, communication) in ASD children are well verified (Dickstein-Fischer, Meltzoff et al, 2011; Nikolopoulos, et al 2010; Wainer et al, 2011; Gillesen et al 2011,). This innovative therapeutic approach was used in infants to follow the robot gaze. The research by Meltzoff and colleagues (2010) demonstrated that social-communicative interaction plays a key role in mediating infants' gaze following of a robot. The robot's humanoid appearance alone was not sufficient to cause gaze following. In older ASD children a humanoid robot called FACE was used in social interaction (Mazzei, et al 2011). The robot was capable of expressing and conveying emotions and empathy. Using FACE robot as a social interlocutor of ASD children real life scenarios where imitated. Preliminary results demonstrated that the platform is well accepted by ASDs and can be consequently used as novel therapy for social skills training.

Robots were used not only in ASD children but also in other disabilities. Palsbo, and Hood-Szivek (2012) explored the efficacy of robotic technology in improving handwriting in children with impaired motor skills. The robotic-guided intervention was effective and might be useful also for ADHD and ASD children. These example studies are evaluated further in this report as part of the technical requirements literature review.

In reference to the literature search many questions might be put to be answer. The project EDUROB is going to answer the following.

2. Objectives and aims of the survey

The general aim of WP2 was to identify the requirements of students with learning disabilities which should be stimulated. This general aim was split into detailed objectives being investigated during the survey and comparison between counties to find the possible areas of students development which might be improved by robot mediated learning. These objectives were to:

1.1. Identify the learning requirements of students with learning disabilities in different European countries

1.2. Describe the preferred teaching strategies of contemporary teachers working with students with learning disabilities, which are used to fulfill the particular requirements in partners countries;

1.3. Investigate teachers' practical experience with ICT usage in contemporary teaching practice

1.4. Identify the teachers' attitudes towards the use of robotics-based technology to stimulate the development of students with learning disabilities.

However the aims 1.1., 1.2. and 1.3 were presented in the report D.2.2. the report D.2.3 presents the particular part of the WP2 survey results, which was dedicated to the 1.4. detailed research aim. It was supposed to investigate the level of teachers, who work with students with learning disabilities, technical experience in using modern technical tools in teaching practice as well as to measure the teachers attitudes towards the usage of robotics-based technology to stimulate the students with learning disabilities development in relationship to the particular special needs. To reach this goal the detailed literature reach was done firstly, which results are presented beneath.

3. Technical Requirements Literature Review

This section aims to summarise findings from an extensive literature review carried out across all partners examining the use of robots within education as examined in academia. In order to gain a consistent method of analysis in keeping with the aims of this particular report a coding sheet (see appendix B) was developed to identify areas of particular relevance to the EduRob project.

This coding sheet analysed literature for who the target groups for robotic interventions currently are, what their particular needs are, how robots can be used to meet those needs and what barriers have been identified that could impact on the introduction of robots as an intervention. The purpose of this report is to examine the ways in which robots have been used as an intervention and what affect they have had on the target user group. Any gaps in research are noted and proposals for going forward made. Finally, the barriers to use and thereby adoption are analysed.

3.1.The Use of Robots

The benefits a robot can provide as an intervention for Special Education Needs (SEN) learners are well stated within literature. Robots can provide a powerful means of engaging difficult to reach learners through a new medium. For instance, they can provide a multi-modal point of interaction for engaging students across varying sensory inputs/outputs (Robins et al., 2005). This therefore gives them a richness of functionality available to them offering and adaptable learning aid (Caprino et al., 2010, Gilleson et al., 2011).

The NAO robot, for example, has sensors for facial recognition, understanding speech and vocalising responses, tactile sensors for touch feedback and is fully programmable allowing it to be directed to walk, dance etc. (Trigo et al., 2014). Given that SEN learners tend to shy away from contact with human peers/teachers, such a robot can provide a social bridge to interaction where interactions with humans can then be improved (Han et al., 2008) and the ways in which they do this are outlined in the following section.

Therefore, a robot can be a social mediator where it is the point of interaction and is semi-responsible for delivering the aims of a teachers session, a peer where the learner collaborates with the robot as a fellow student would or a tool where manipulating the robot is some way achieve the goals of a learning session (Mubin et al., 2013).

3.2.Evaluation of Studies

This section summarises some of the studies that currently utilise robots as an intervention for learners with Special Education Needs (SEN). The robot used is noted, the method of experiment and the observable outcomes from it.

3.2.1.Humanoid Robots

Standen et al. (2014) used the NAO robot in a series of case studies with 12 students; with each having four separate sessions with the robot. A variety of learning outcomes were used based on the individual needs of the learner formed in discussion with the teacher. Such learning outcomes include: improve verbal communication, develop patience and spelling ability, learn cause and effect, switch activation, obey commands, learn to use a joystick similar to a wheelchair and holding objects. Such a range of learning outcomes is indicative of the flexibility the robot offers due to its multi-modal interface. The level of engagement with the tasks was measured over time and used as an indicator for a successful teaching session; “Engagement is the single best predictor of learning”. Initial reports suggest that engagement over time increased with the robot; however, there is a need for a more longitudinal study.

The feasibility of using the NAO robot as an intervention was also explored by Malik et al. (2013), here 5 pre-programmed behaviours were used to pilot the NAO robot as an effective learning tool. In a short, small trial with two participants exhibiting mild autism, quantitative methods and input from a clinician suggested increased optimism for the robot and no visible autistic behaviour during the session. Clearly, a more longitudinal view with a larger sample is required but the ability to pre-program activities show the strength of the robot in providing a low maintenance teaching tool.

Mazzei et al. (2011), developed a humanoid robot called FACET with realistic facial expressions aimed to teach empathy and convey emotion to children with autism. In a preliminary trial of 6 male subjects (4 with Autism Spectrum Disorder (ASD) and 2 control) Initial results suggest favourable interaction with the robot, particularly during conversation. However, it should be noted that this is a small scale trial and has an unfair control (higher age range among the two control students).

Dautenhahm et al. (2002), developed the Robota robot aimed at encouraging imitation behaviour where the teacher directed the interaction. A trial with 14 autistic children with one-two sessions with the robot suggested participants engaged in imitation behaviour when observed and generally seemed to enjoy the session. Again, however, the trial is limited and observable engagement may be due to the novelty of the technology; longitudinal studies required.

3.2.2.Other

Kim et al. (2013), explored the differences between varying types of teaching methods in attempting to engage children with autism; specifically, the effects of a human, robot dinosaur and touchscreen game. An experiment examined the social behaviours of 4-12-year-old children with autism spectrum disorders (N = 24) finding that children spoke more to the adult confederate when the interaction partner was the robot compared to the human or game.

The Lego NXT robot was used to explore social interaction among learners with ASD (Nikolopoulos et al., 2010) where it is described as a cost effect method of intervention to assisting social behaviour. Similarly, Wainer et al. (2009) explored the use of this robotic solution to encourage collaborative play in student with high functioning autism over a period of four months (one of the more longitudinal studies available). Findings suggest that the amount of enjoyment correlated with the collaborative behaviour exhibited and the intervention here provides a means of increasing enjoyment with the learning process.

A separate Lego based intervention, the Mindstorm, was used to encourage problem based learning in students with a range of SENs (Karna-Lin et al., 2006). This took the form of a series of afternoon clubs during which the robot form the point of interaction with 5 groups of 7-10 students. Play appeared more sociable and collaborative with qualitative measures suggested that more difficult concepts appeared to be more easily grasped. However, it is worth noting the lack of rigour in gathering data and its place in an after school club – how would such an intervention form part of the everyday curriculum?

Lego Mindstorms were also used to teach language with a target group of 24 students interacting with the intervention over a 7 week period (Mills et al., 2013). Here problem solving was used to encourage collaboration and therefore speech during sessions. Such research demonstrate the adaptability of the solution in tackling the varying needs of the target group using just one kind of device.

Park et al. (2012), conducted an experiment to determine if learners (children and adults) with autism exhibit different eye-fixation patterns when looking at human faces compared to machine-like faces and robotic humanoid faces. Between-subject in design utilised suggesting that children focussed more on the mouth of machine like and humanoid like robots when compared to an actual human. This supports the suggestion made earlier that learners with ASD interact more with technology due to their innate fascination and the lack of complexity that may be found with their human counterparts.

Similarly, Bekele et al. (2013), examined the use of an intelligent robot which was tested for feasibility for teaching children with ASD. This robot is capable of administering joint attention prompts and adaptively responding based on in system measurements of performance. A small test sample (6) demonstrated that ASD children spent more time looking at the robot than human counterparts (compared to 6 typically developing learners). Again, a small sample and limited timeframe – a more diverse range of prompts are needed and observation perhaps are due to the novelty of the robot, which may fade over time.

This review of current research projects utilising the use of robots is intended to demonstrate the range and variety of tools available as well as some preliminary results that suggest robots can provide an effective intervention within this problem domain. Tables 3 and 4 summarise the robots examined here and their various capabilities; this is intended to inform the use of robots with the EduRob project.

3.3.Barriers

Finally, the potential barriers to adoption are listed in this section. These could be technical limitations to the technology as well as gaps in the research methods applied that need to be addressed in order to fully assess the use of robots as an effective intervention.

First, literature up to this point suggests the need for an adaptable solution that caters for the variety of needs present in the target audience. This requires the range of sensors to be all encompassing and accurate such that they do not frustrate or themselves impede the learning process. Indeed, robots can add value but it must be a tailored experience (Klein et al., 2014). There is a suggestion in literature that the sensors may not be sophisticated enough (Standen, Brown et al, 2014) (Werry and Dautenhahm, 1999) (Hedgecock, 2013) and that speech recognition functionality may not be sophisticated enough to cope with the impediments the learner may have (Kim et al., 2013).

Furthermore, variety would suggest there is a need for a scenarios and activities to be quickly deployed and implemented within the classroom for an effective intervention that caters for diversity but does not take time to set-up. Research has suggested the creation of programming blocks that can be strung together to make simple tasks and sent to the robot (Gilleson et al, 2011).

To expand, the teachers ability to control the robot during the session must be easy and straightforward and require little to no programming knowledge (Trigo, 2014, Cristoforis, Pedre et al, 2012). This is particularly true as the favoured method of implementing session appears to be to take a “Wizard of Oz” style approach where the Robot appears to be autonomous but is controlled by the teacher (Steinfeld, Jenkins and Scassellati 2009 cited in Kim et al., 2013).

Given the unique requirements here there perhaps could be a suggestion that specifically designed technology is required. This is inevitable expensive to buy, code and implement (Altin et al., 2010, Cooper et al., 1999). In particular, early intervention and continuous care provide significantly better outcomes in the long-run. Currently, there are no robots capable of meeting these requirements that are both low-cost and available to families of autistic children for in home use (Dickstein-Fischer et al, 2011). However, off the shelf solutions such as the Lego range can provide cost effective and adaptable by design solutions (Nikolopoulos et al., 2010).

Finally, the current limitations found within research. Studies tend to have a small sample size (Allison et al., 2011) and rely on research methods that lack a degree of rigour (Barretto & Bennitti, 2012); i.e. results are based on limited observations that require some interpretation. Furthermore, diversity in the range of disabilities even with one particular diagnosis make it difficult to determine the cause of observed effects (Allison et al, 2011). Therefore, there is a need to ensure samples have a range of ages and genders to overcome this limitation (Park et al, 2012).

A number of these studies tend to be small scale in terms of time given to data collection. This is an issue given that the robots used are understandable novel and exciting to the learners which may impact on the observation made. There is a need, therefore, for more longitudinal studies (Bekele et al, 2013).

This literature review has examined the ways in which robots are currently used by research to address the needs of SEN learners. Currently, there is little work examining how robots could be implemented within a longitudinal study and as part of standard teaching practice. Before this can be done, however, a pedagogy must be designed that allows for the adaption and implementation of robots as an effective intervention that can be part of a teachers everyday teaching toolkit. This literature review and the following survey discussion aims to inform the design of this pedagogy that will form the main output from WP3.

Table 3. Psycho-educational activities supported by robotics

	Robotic platform	psycho-educational activities: gaze monitoring and role playing	Imitation (voice, gestures, movements)	Learning sequences	New kinds of activities development	modelling interventions strategies	communication and conversational turn taking training activities.	stimulating cognitive and controlling skills (executive function and management skills)	mediating social interaction	reinforcement of good behaviour	**Target group(s)**	**Barriers/facilitators for introducing in learning contexts**
Humanoid	NAO	+	+	+	+	+	+	+	+	+	ASD, ID, MD, TDL	Requires good technical competences for new apps development/high price
	FACET	-	+	-	-	-	+	-	-	-	ASD	Not on the market
	Robota	-	+	-	-	-	-	-	-	-	ASD	Not on the market
Others	LEGO Mindstorms NXT	-	-	+	+	+	+	+	+	+	ASD, ID, TDL	Mainstream product/affordable price
	LEGO Mindstorms EV3	-	-	+	+	+	+	+	+	+	ASD, ID, TDL	Mainstream product/affordable price
	Dinosaur	-	-	-	-	-	+	-	-	-	ASD	

Notes: +/-, indicate that the robotic platform resulted suitable/not suitable for that specific psychoeducational activity as found either in the sytakeholders' survey or in the literature interview; ASD, Autism Spectrum Disorder; ID, Intellectual Disability; MD, Multiple Disabilities; TDL, Typically developing learners

Table. 4. Popular educational robotics platforms

Name	Educational level	Features	Programming languages	Place of origin
Arduino Robot[1]	Secondary, Vocational Education, University	MOBILE ATmega32u4 microcontroller 32KB flash memory, keypad, full color lcd, sd card reader, speaker	Arduino	Italy
Thymio II robot[15]	Primary, Secondary, Vocational Education, University	MOBILE 16 bit PIC24 processor	ASEBA scripting language	Switzerland
Robotino[16]	Vocational Education, University	MOBILE Intel Atom, 1.8 GHz, dual core, 4 GB RAM, 32 GB SSD Various sensors, Full HD Camera	C, C++, Java, .NET, Matlab, Labview and MS Robotics Developer Studio	Germany
Lego Mindstrom NXT[17]	Secondary, Vocational Education	STEM EV3 Brick control center and power station, 4sensors, 4 motors, USB port, micro SD card port, built-in speaker	Lego Mindstorms EV3	Denmark
Robotis Play[18]	Primary, Secondary	STEM CM-150 controller embedded with buzzer, mic and 3x IR sensors, Touch sensor, IR sensor, RC-100B remote control and bluetooth module	R+ Task (C-based GUI)	Korea
Fischertechnik Computing[19]	Primary, Secondary, Vocational Education	STEM Module Robot TX is based in 32-bit ARM 9 processor, 8 MB RAM, 2 MB flash, display (128x64 pixel), monochrome	Propetary app. "ROBO Pro", C compiler	Germany
Engino Robotics ERP[20]	Primary, Secondary, Vocational Education	STEM 32-bit ARM CORTEX-M2 micro controller, 256 Kbytes FLASH, 64 Kbytes RAM	ERP Software	Cyprus
Aldebaran NAO[21]	All Levels	HUMANOID Intel Atom @ 1.6 GHz two HD cameras, four microphones, sonar range finder, two infrared emitters and receivers, inertial board, nine tactile sensors, eight pressure sensors Ethernet, Wi-Fi	Chorographe C++, Python, Java, Matlab, Urbi, C, .Net	France
Robotis Bioloid Premium[22]	Secondary, Vocational Education	HUMANOID Controller CM-700 based in Atmel ATMega2561 embedded mic, mini USB port, 1 gyro sensor, 1 distance sensor, and 2 IR sensors	Robo+ Task Robo+ Motion	Korea
Robotis Darwin OP[23]	University	HUMANOID 1.6 GHz Intel Atom Z530 on-board 4GB flash SSD, 20 actuator modules (6 DOF leg x2+ 3 DOF arm x2 + 2 DOF neck)	Linux Open platform	Korea

RoboKind Zeno R-25[24]	University	HUMANOID OMAP 4460 dual core 1.5 GHz ARM Cortex A9 processor with 1 GB of RAM and 8 GB of memory, wifii and bluetooth.	Java	USA

4. Methodology

4.1 Method

The Survey Questionnaire (English version) was created to measure the students requirements as well as teaching strategies employed by teachers so that these could be taken into account in the development of guidelines for the innovative use of robotics. The Questionnaire developed to gather quantitative data informing the students' is shown in Appendix A. The Questionnaire sought to gather data from key stakeholders in the learning process with a focus on teacher and therapists in special education.

The Questionnaire included questions dealing with the following areas:

a) professional characteristics (gender, age, teaching experience, ICT familiarity and usage in teaching practice),

b) students' characteristics (age, disability, support needed – described on the scale: 0=the lack of support needed, students active on their own, 1= with minimal help, 2=with considerable help, 3=students do not active at all).

c) Students' educational and developmental requirements (at educational and social level) were analysed as following, perception, memory, thinking strategies, executive functions, communication skills, general knowledge and detailed knowledge, as well as basic key competences (such as: reading, writing, calculation, ICT).

d) teachers' teaching strategies in regular practice (such as: activity based teaching, learning through discovery, modeling, collaborative learning, instructional)

e) ICT familiarity and usage in teaching practice

f) Teachers' attitudes towards robotics in education.

The Survey Questionnaire was translated into national languages and either filled in by respondents or by a researcher on behalf of the respondent(s) during a face to face interview or focus group.

4.2.Respondents profile

There were 272 questionnaires filled in total. The amount of particular national subgroups is given in the table 1.

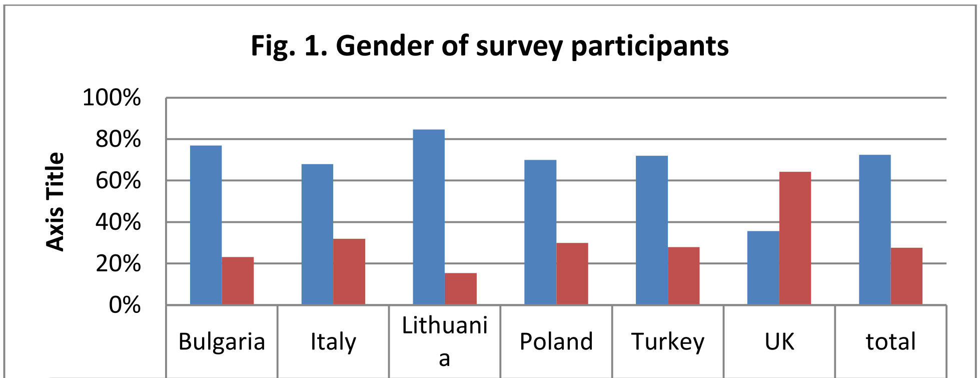
Table 1. Number of Respondents per country collected by partners

Country/ Partner	Numbers of respondents	email/ internet	interview (face to face, Focus group)
Bulgaria/ Interproject	52	0	52
Italy/	50	42	8

Europole			
Lithuania/ Hiteco	52	52	-
Poland/ Pedagogical University	50	0	50
Turkey Sulyeman Sa University	50	10	40
UK/ Nottingham T University	18	8	10
TOTAL	272	112	160

The change from the agreement was due to the difficulties in contacting professionals willing to participate in the survey. Participants in the UK noted that the survey was not an effective means of addressing the complexity of their teaching practice.

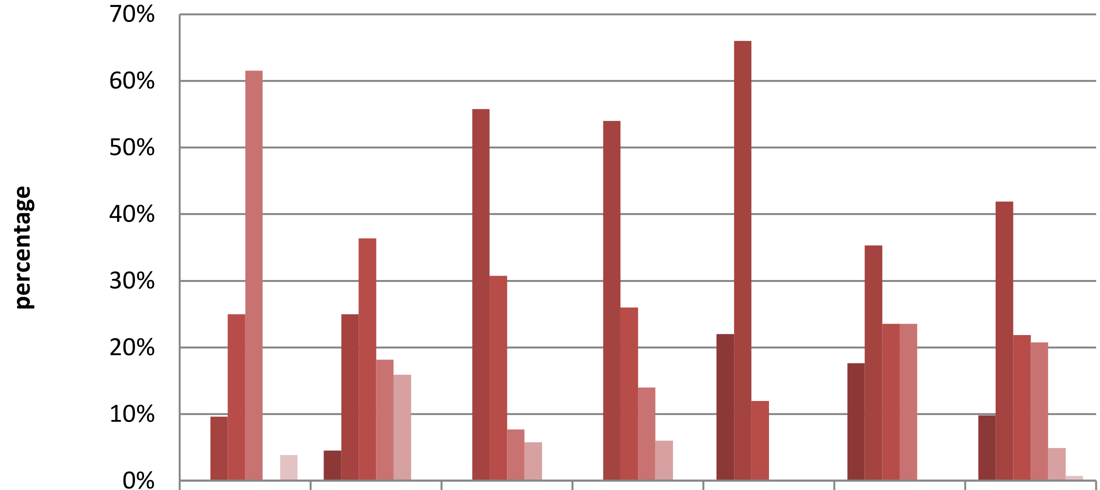
The total respondents sample was dominated by females as well as almost all national subgroups of participants were with only one exception. In UK there was the dominance of males in the tested subgroup (females -36%; 64% - males). The detailed gender differentiation is given in the Fig.1.



	Bulgaria	Italy	Lithuania	Poland	Turkey	UK	total
Female	77%	68%	85%	70%	72%	36%	72%
Male	23%	32%	15%	30%	28%	64%	28%

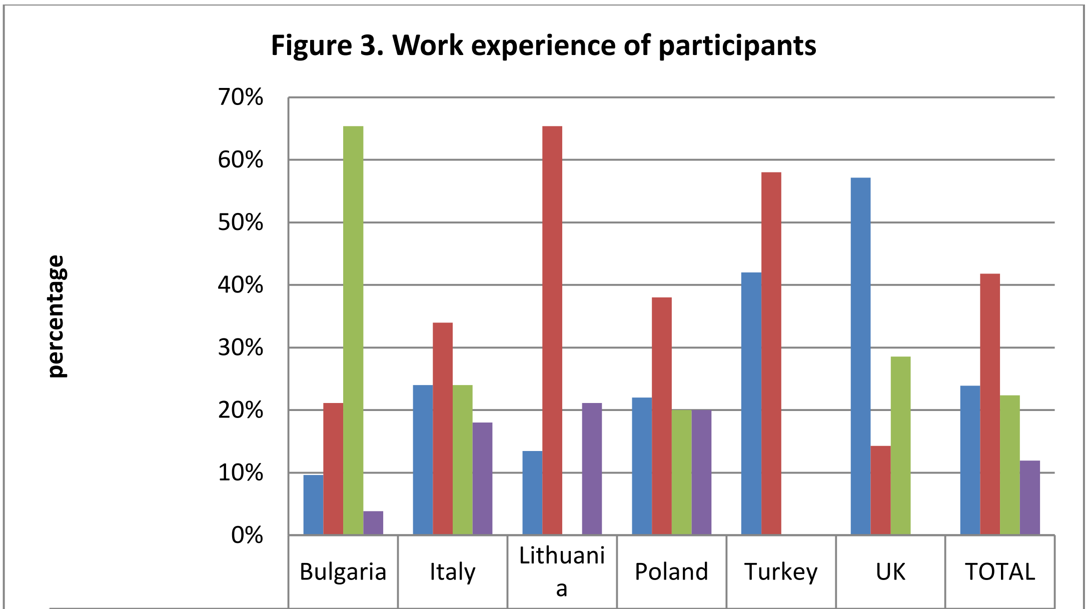
The respondents differed in age however young adults (aged between 25 and 35) represented more than 40% of the total sample. In five national samples most participants were also between 25 and 35 years however in two countries the majority of the participants were older. In Bulgaria over 60% of participants were aged over 45 years, and in Italy 70% were aged over 35. The detailed description of participants' age is given in the Fig. 2

Figure 2. The age of survey participants



	Bulgaria	Italy	Lithuania	Poland	Turkey	UK	TOTAL
till 25 years	0%	5%	0%	0%	22%	18%	10%
25-35 years	10%	25%	56%	54%	66%	35%	42%
36-45 years	25%	36%	31%	26%	12%	24%	22%
46-65 years	62%	18%	8%	14%	0%	24%	21%
56-65 years	0%	16%	6%	6%	0%	0%	5%
>65 years	4%	0%	0%	0%	0%	0%	1%

The survey participants differed in the length of time they had worked with students with learning disabilities. In the total sample over 40% of participants had work experience between 10 and 15 years. However in two countries the pattern was different. In England more than half of the subgroup had got shorter period of work experiences in contrast to Bulgaria where most of the participants were highly experienced having more than 16 years' experience. The detailed data are given in the Fig. 3.



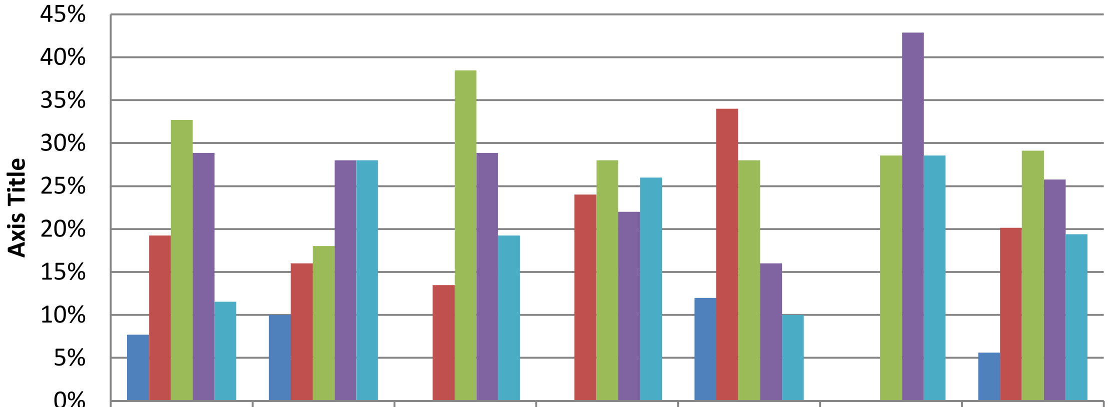
	Bulgaria	Italy	Lithuania	Poland	Turkey	UK	TOTAL
5-9 years	10%	24%	13%	22%	42%	57%	24%
10-15 years	21%	34%	65%	38%	58%	14%	42%
16-25 years	65%	24%	0%	20%	0%	29%	22%
26 years and more	4%	18%	21%	20%	0%	0%	12%

5. Survey results

5.1. Teachers' familiarity with educational technology (ICT)

In total survey sample the familiarity with ICT and educational technology is fair and pretty good (near 30% of respondents marked this). However there is some international difference. The UK subgroup is the most advanced in ICT professional subgroup due to the fact that there was no person who was neither unfamiliar with ICT nor with low experience in using such items. In Poland, Bulgaria and Lithuania the most of participants declared fair familiarity with ICT however in Turkey the ICT familiarity for more than 30% of respondents was rather low. The detailed data of familiarity with ICT and educational technology are given in the Fig 4.

Fig. 4. Familiarity with educational technology ICT



	Bulgaria	Italy	Lithuania	Poland	Turkey	UK	TOTAL
None	8%	10%	0%	0%	12%	0%	6%
Low	19%	16%	13%	24%	34%	0%	20%
Fair	33%	18%	38%	28%	28%	29%	29%
Good	29%	28%	29%	22%	16%	43%	26%
High	12%	28%	19%	26%	10%	29%	19%

5.2. Educational technology in school practice as the tool for students learning and developmental requirements fulfilment

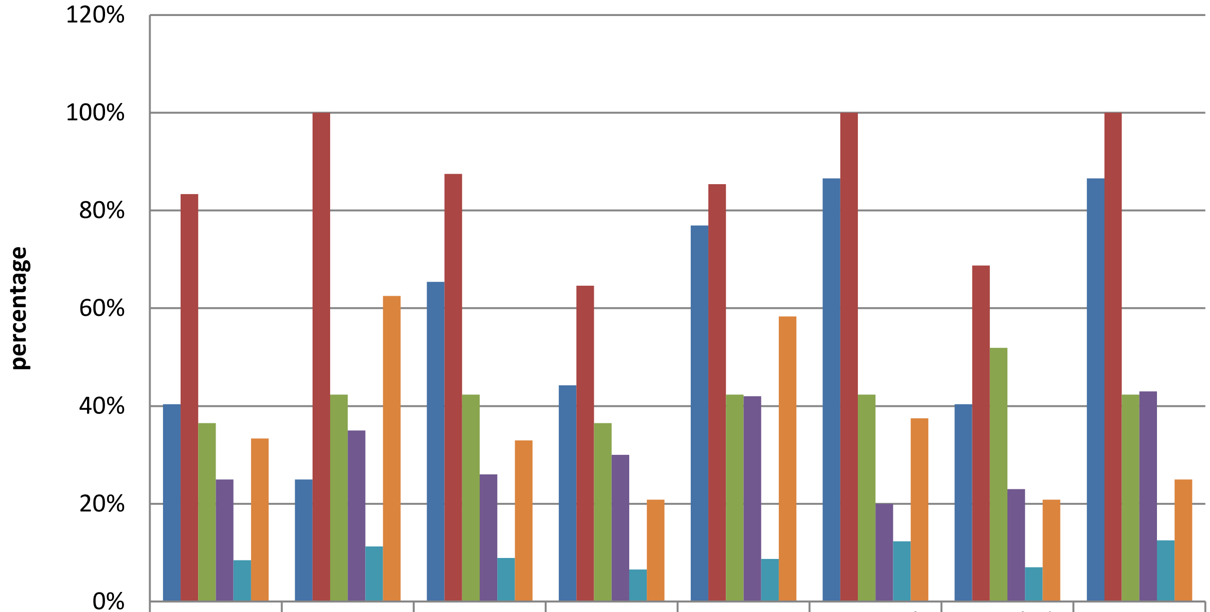
The respondents were asked to identify the developmental and educational student's needs (the results were presented in report D.2.2) which are supported by using the educational technology in their daily teaching practice. Teachers were to point particular ICT items which they are usually working with (eg. interactive whiteboards, mobiles, iPads, games, virtual worlds, simulations, robot, etc.) or just to reflect the ICT usage in general. To make the results comparable the percentage of general ICT usage was computed.

The most advanced with using ICT in teaching practice were in generally Italian teachers. They use educational technology tools to improve all analysed cognitive skill and educational needs. Teaching supported by educational technology in other countries was more differentiated. However in Bulgaria was intensity of this support was also very high in four controlled area (thinking strategies, communication skills, general knowledge and basic key competences in contrast to perception, memory, executive function and detailed knowledge. In England ICT tools were used usually to improve memory as well as communication skills however these tools were less intensively used to increase general and detailed knowledge, basic key competences, perception and executive function.

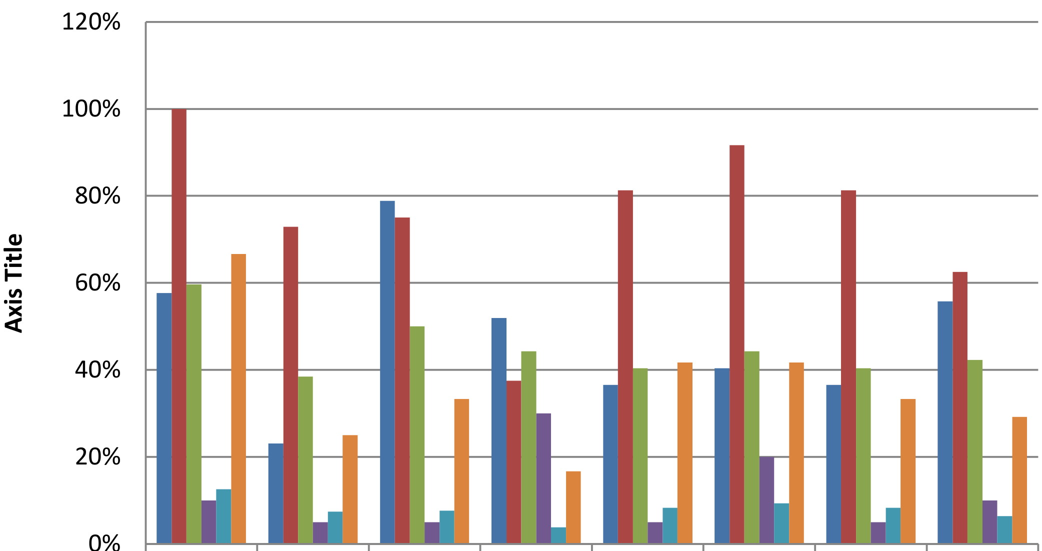
In Poland the usage of ICT in teaching practice was presented at lower level as in Lithuania however the pattern of results was similar. The less intensive usage of ICT tool was observed in Turkey.

Social needs are also fulfilled with ICT technology tools mostly in Italy in contrast to Poland and Turkey. Detailed results are given in the Fig. 5a and the Fig. 5b.

Fig. 5a. ICT educational technology toools in the students' educational needs fulfillment



	Perception	Memory	Thinking strategies	Executive functions	Communication skills	General knowledge	Detailed knowledge	Basic Key competences
Bulgaria	40%	25%	65%	44%	77%	87%	40%	87%
Italy	83%	100%	88%	65%	85%	100%	69%	100%
Lithuania	37%	42%	42%	37%	42%	42%	52%	42%
Poland	25%	35%	26%	30%	42%	20%	23%	43%
Turkey	8%	11%	9%	7%	9%	12%	7%	13%
England	33%	63%	33%	21%	58%	38%	21%	25%

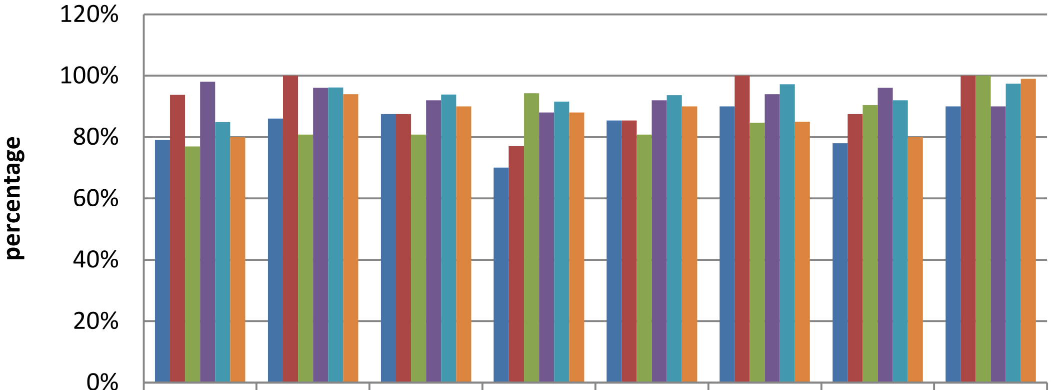


	Social learning	Theory of mind	Task management skills	Accuracy and precision	Conscientiousness and sense of duty	Self-presentation skills	Knowing one's own pros and cons	Mental persistence
Bulgaria	58%	23%	79%	52%	37%	40%	37%	56%
Italy	100%	73%	75%	38%	81%	92%	81%	63%
Lithuania	60%	38%	50%	44%	40%	44%	40%	42%
Poland	10%	5%	5%	30%	5%	20%	5%	10%
Turkey	13%	7%	8%	4%	8%	9%	8%	6%
England	67%	25%	33%	17%	42%	42%	33%	29%

5.3. Teachers abilities towards robotics education

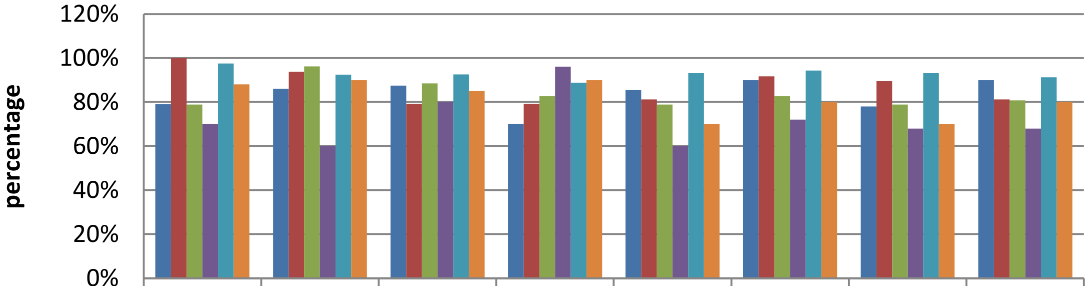
In reference to the question about the teachers opinion on the educational robotics more than 70 % respondents found this proposal interesting and useful in dealing with educational as well as social developmental problem of disabled student. Detailed results are given in the Fig. 6a. and the Fig. 6b

Fig.6a . Teachers' attitudes towards robots in supporting disabled students at educational level



	Perception	Memory	Thinking strategies	Executive functions	Communication skills	General knowledge	Detailed knowledge	Basic Key competences
Bulgaria	79%	86%	88%	70%	85%	90%	78%	90%
Italy	94%	100%	88%	77%	85%	100%	88%	100%
Lithuania	77%	81%	81%	94%	81%	85%	90%	100%
Poland	98%	96%	92%	88%	92%	94%	96%	90%
Turkey	85%	96%	94%	92%	94%	97%	92%	97%
England	80%	94%	90%	88%	90%	85%	80%	99%

Fig.6b Teachers' attitudes towards robots in supporting disabled students at social level

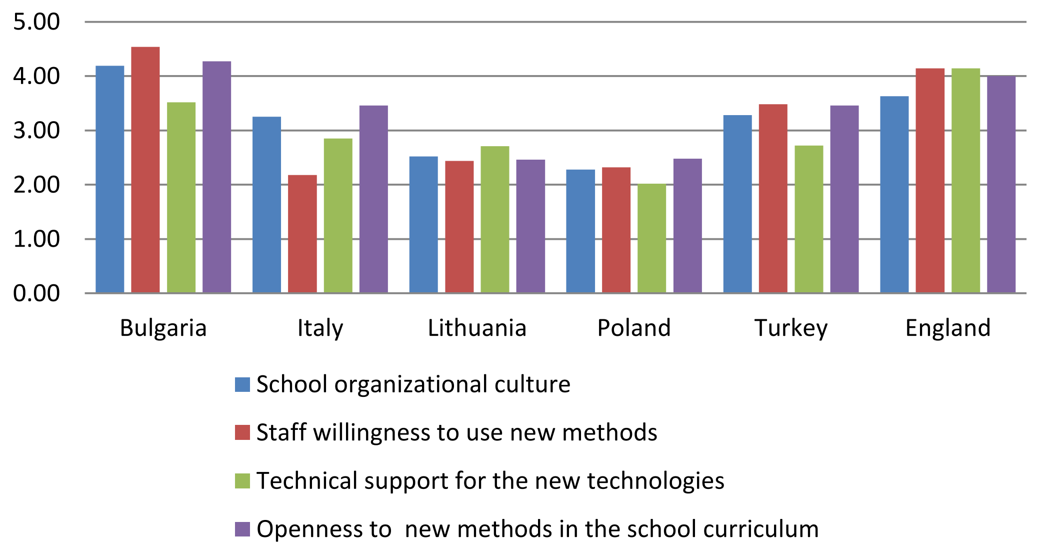


	Social learning	Theory of mind	Task management skills	Accuracy and precision	Conscientiousness and sense of duty	Self-presentation skills	Knowing one's own pros and cons	Mental persistence
Bulgaria	79%	86%	88%	70%	85%	90%	78%	90%
Italy	100%	94%	79%	79%	81%	92%	90%	81%
Lithuania	79%	96%	88%	83%	79%	83%	79%	81%
Poland	70%	60%	80%	96%	60%	72%	68%	68%
Turkey	97%	92%	93%	89%	93%	94%	93%	91%
England	88%	90%	85%	90%	70%	80%	70%	80%

5.4. School support for the use of robots in the classroom

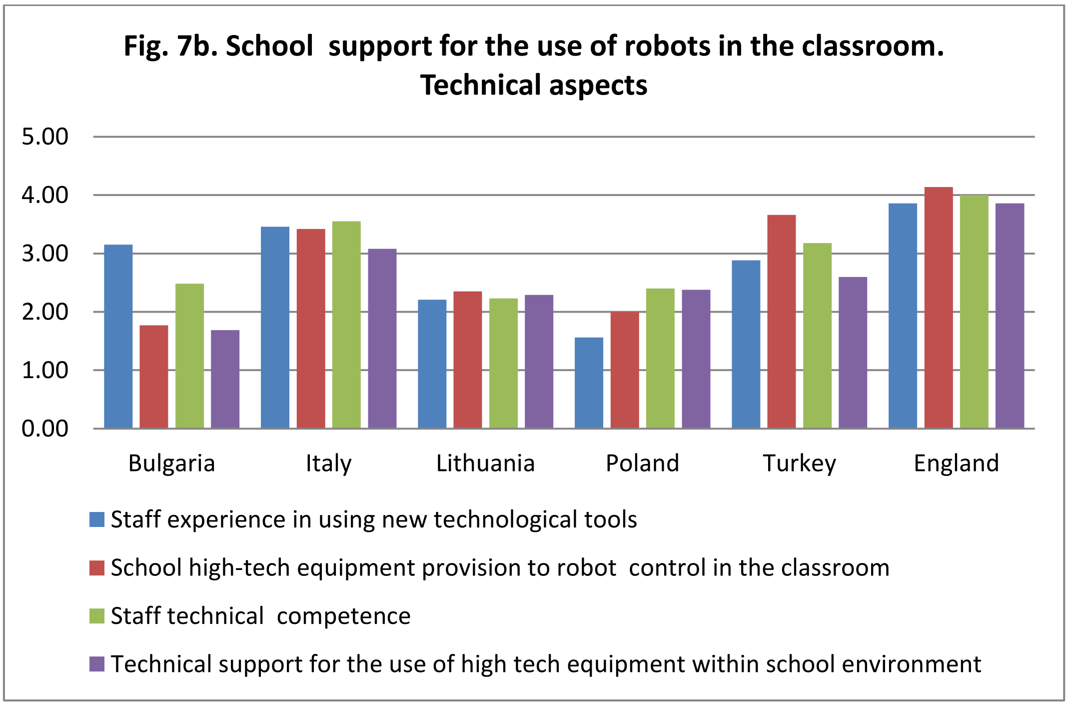
The new technology and new didactic methods need positive atmosphere at school context to be implemented. The school support for the use of robots in the classroom was analysed in reference to its organizational aspects. The school support for use of robots was slightly differentiated in the context of nationality of tested subgroup. The school organizational culture seems mostly acceptable for new robotics pedagogy in teachers' perception in Bulgaria and England, slightly lower acceptance was expected in Turkey and Italy, the lowest acceptance was in Poland and Lithuania. Staff is highly willing to use new methods also in Bulgaria and England in contrast to Italy, Poland and Poland where the staff might be more opponent. Technical support for new technology was highly accepted in England and Bulgaria in contrast to lowest approval in Poland. However openness to new methods in the school curriculum are mostly expected in England and Bulgaria in contrast to Poland where the school curriculum should be adjusted to the individual special needs but in general it is organized at national level. Detailed data are presented in the Fig 7.a.

Fig.7.a. School support for the use of robots in the classroom. Organisational aspects



The new technology and new didactic methods need technical support at school context to be implemented. The school support for the use of robots in the classroom was analyzed in reference to its technical aspects. The school support for use of robots was differentiated in the context of nationality of tested subgroup.

The technical aspects of school support for use of robots were more differentiated in the context of nationality of tested subgroup than organizational aspects. The staff experience in using new technological tools seems to be diversified. The higher experience in using new technology was presented by English teachers in contrast to lower experience of Polish respondents. The other national subgroups (Bulgaria, Italy, Turkey and Lithuania) express common level of experience. School high-tech equipment provision to robot control in the classroom as well as staff technical competence are at the higher level in England, Italy and Turkey however in other three countries (Poland Lithuania and Bulgaria) it is perceived by teachers as significantly lower. Intensive technical support for the use of high tech equipment within school environment is expected by teachers in England, Turkey and Italy in contrast to teachers from Poland, Lithuania and Bulgaria who find it difficult to get technical support for the use of high tech equipment within particular school environment where they work. Detailed data are presented in the Fig 7.b.



5.5. Using robots to help students meet their learning and developmental requirements – in respondents opinion

In respondents' opinion using robots student can develop communication and social competences, numeracy as well as executive functions. The engagement in human-robot interaction will give many positive emotions. Will increase motivation to do certain tasks. It will help to engage, energize, to bring attention, increase learning motivation. Robot with its own functions can be a good assistant in all learning areas (can help) in maths the robot could engage students by his example executing instructions and motivate students to perform tasks better.

Children will learn to use new technologies. It would be novelty for students. It may help for shy students to become more communicative. Seeking to teach students various skills it is not enough only to instruct them. It is necessary to use attractive, interesting and motivating tools.

All students like very much various ICT tools – there are interested and memorize learning material better when it delivered through ICT. Many teachers use these tools to make the lessons more attractive and communicative. Respondents are also interested in new educational robotics as the new tool for developing students ability at the educational as well as social level.

Respondents also shared that students with intellectual disabilities or learning disabilities (for example children with Down syndrome), might have trouble playing with robots because of their intellectual limitations and cognitive disabilities. They have reduced ability to retain attention and might not understand the meaning of proposed play, and/or the meaning of the language used to play; some also have speech limitations. However even in severe disability appropriate way of human-robot interaction might be find.

It was discussed the possibility for training activities like: Imitation, Action and Coordination, and Symbolic Play, each one playing a major role in the development of disabled children/students. Imitation activities involve attention keeping and observation, the physical control to replicate and reciprocal coordination. Individuals engaged with Imitation exercises might be able to focus their attention on the behaviour of the other, creating a model of this behaviour to replicate with their own abilities. Action and Coordination activities involve movement, spatial orientation and coordination. Individuals engaged with these activities might be able to navigate the surrounding space, detect the presence and the movement of objects and autonomously move, or ask to be moved through the space. Symbolic Play activities involve shared attention, imagination, pretending, and role-playing. Individuals engaged with Symbolic Play might be able to start or join playing with symbols and objects with symbolic values. They may also be able to follow a symbolic storytelling activity and take part with appropriate (coherent and meaningful) contributions.

There were also respondents which shared that Robots are a great aid to the teaching of especially science like Maths and Physics because they imagine the robots' power to capture the imagination of younger people with disabilities.

Some respondents shared that they are expecting the robots to enable students being facilitated to undertake a wide range of tasks that would be otherwise denied them because of their disabilities. Accessible interfaces of educational robots can lead to disabled students having equal participation with peers in robot based leaning activities.

6.Scientific conclusions

The WP2 was aimed to describe the engagement of ICT technology tools in the process of developmental stimulation and teaching students with special needs. This was the general basis for assess teacher attitudes towards the use of robotics technology to provide a significant impact on students' learning achievements.

The survey in six partners countries was conducted to meet these aims by administering the specially developed questionnaire. There were 272 questionnaires filled in total.

The results show that respondents presented positive attitudes towards educational robotics in all partner countries. They found that robots could help students in education and training to understand better collaboration, natural sciences, develop good level problem solving skills. Robots also could act as a bridge in enabling students to understand humans. For example, students can learn how speech is processed by humans by considering how robots recognize speech. This fits with the aspect of constructionism where learning is a function of what students know in the real world and what they infer in the virtual world. Analogous to the theory of constructionism lie on the principles of active learning and learning by design that advocate a hands-on approach to increase the motivation of students.

Howevre teachers find robots as the intersting and useful tool they need to be reassured that the intention is not to replace them with robots but rather provide them with a teaching tool/aid that can complement the learning experience and motivate of the students.

The majority of the respondents concluded that the robots cannot replace human teachers but they are expected the added value that robots can bring to the classroom in the form of a stimulating, engaging and instructive teaching aid

7. Recommendations and implications for WP3 and WP4

There is a necessity of awareness rising of the possibilities which robots can potentially offer to the mainstream and special education due to the fact that robots are becoming an integral component of our society and have great potential in being utilized as an educational technology.

In this view, on the basis of the data here discussed (see also D2.2), we have attempted to link the main robotic platforms, available for educational and clinical use, with the target psycho-educational activities identified either by the stakeholders involved so far in the Project or in the literature review. From this, possible robotic platforms are listed in tables 3 and 4; it is intended to guide researchers in the next phase of the Project and to be a first technical reference for the further technical and pedagogical developments. Results from both this literature review and survey suggest that many differing robots can be used in a variety of ways to address multiple needs across a single learner cohort. The questions remaining for WP3 include: what robots should be used, how might they be used and how will they fit within current teaching practice with a longitudinal view.

In general, this report has begun to demonstrate the use of technology within the classroom for addressing the needs of learners with SENs. WP3 will build on this and identify how robots can provide a beneficial addition to the teaching toolkit and, furthermore, examine how they can be integrated into current teaching practice. There is a need to identify specific example uses of the robot and how that fits with any national curricula while being respectful of the differences between partners requirements in this regard. Building on this, there is a need for in-depth teacher input with regard to how robots can be implemented and what might prevent a successful implementation. The development of a robot-based pedagogy must address these needs while being an effective and viable addition to current teaching methods such that the potential of robots as an intervention is achieved.

8. References

Allison L., and Brooke R. Ingersoll. "The use of innovative computer technology for teaching social communication to individuals with autism spectrum disorders." *Research in Autism Spectrum Disorders* 5.1 (2011): 96-107.

Altin, Heilo, and Margus Pedaste. "Learning approaches to applying robotics in science education." *Journal of baltic science education* 12.3 (2013): 365-377.

Bekele, Ephrem T., et al. "A step towards developing adaptive robot-mediated intervention architecture (ARIA) for children with autism." *Neural Systems and Rehabilitation Engineering, IEEE Transactions on* 21.2 (2013): 289-299.

Benitti, Fabiane Barreto Vavassori. "Exploring the educational potential of robotics in schools: A systematic review." *Computers & Education* 58.3 (2012): 978-988.

Besio, Serenella, Francesca Caprino, and Elena Laudanna. "Guidelines for using robots in education and play therapy sessions for children with disabilities." *Uniservice, Trento* (2010).

Cooper, M, David Keating, and Kerstin Dautenhahn William Harwin. "Robots in the classroom-tools for accessible education." *Assistive technology on the threshold of the new millennium* 6 (1999): 448.

Dautenhahn, Kerstin, and Aude Billard. "Games children with autism can play with Robota, a humanoid robotic doll." *Universal access and assistive technology*. Springer London, 2002. 179-190.

De Cristoforis, Pablo, et al. "A Behavior-based approach for educational robotics activities." *Education, IEEE Transactions on* 56.1 (2013): 61-66.

Dickstein-Fischer, L., Alexander, E., Yan, X., Su, H., Harrington, K., Fischer, G.S. (2011). An affordable compact humanoid robot for autism spectrum disorder interventions in children. *Conf Proc IEEE Eng Med Biol Soc* pp. 5347-51

Dickstein-Fischer, Laurie, et al. "An affordable compact humanoid robot for autism spectrum disorder interventions in children." *Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE*. IEEE, 2011.

Galvez Trigo, Maria Jose, and David J. Brown. "Remote operation of robots via mobile devices to help people with intellectual disabilities." *Interactive Technologies and Games (iTAG), 2014 International Conference on*. IEEE, 2014.

Gillesen, J. C. C., Barakova, E. I., Huskens, B. E. B. M., & Feijs, L. M. G. (2011). From training to robot behavior: towards custom scenarios for robotics in training programs for ASD. In: 2011 IEEE International Conference on Rehabilitation Robotics, 2011: 5975381.

Han, Jeong-Hye, et al. "Comparative study on the educational use of home robots for children." *Journal of Information Processing Systems* 4.4 (2008): 159-168.

Hedgecock, J.: Can working with a robot enhance learning in pupils with intellectual disabilities? B Med. Sci. Dissertation submitted to the University of Nottingham (2013)

Jordan, Kimberlee, et al. "Feasibility of using a humanoid robot for enhancing attention and social skills in adolescents with autism spectrum disorder."*International journal of rehabilitation research* 36.3 (2013): 221-227.

Kärnä-Lin, Eija, et al. "Can robots teach? Preliminary results on educational robotics in special education." *Advanced Learning Technologies, 2006. Sixth International Conference on*. IEEE, 2006.

Kim, Elizabeth S., et al. "Social robots as embedded reinforcers of social behavior in children with autism." *Journal of autism and developmental disorders* 43.5 (2013): 1038-1049.

Klein, Tanja, et al. "Evaluation of short term effects of the IROMEC robotic toy for children with developmental disabilities." *Rehabilitation Robotics (ICORR), 2011 IEEE International Conference on*. IEEE, 2011.

Mazzei, D., Lazzeri, N., Belleci, L., Igliozzi, A., Mancini, A., Ahluwalia, A., Muratori, F., De Rossi, D. (2011). Development and evaluation of a social robot platform for therapy in autism. *Conf Proc IEEE Eng Med Biol Soc.* pp. 4515-4518

Meltzoff, A.n., Brooks, R., Shon, A.P., Ra, R (2010). Social robots are psychological agents for infants: A test of gaze following. Neural Networks , 23 8-9, 966-972

Mills, Kathy A., Vinesh Chandra, and Ji Yong Park. "The architecture of children's use of language and tools when problem solving collaboratively with robotics." *The Australian Educational Researcher* 40.3 (2013): 315-337.

Mubin, Omar, et al. "A review of the applicability of robots in education." Journal of Technology in Education and Learning 1 (2013): 209-0015.

Nikolopoulos, C., Kuester, D., Sheehan, M., Dhanya, S., Herring, W., Becker, A., Bogart, L. (2010). Socially Assistive Robots and Autism. *Solid State Phenomena*, Vols. 166-167, pp. 315-320,

Park, Eunil, Ki Joon Kim, and Angel P. del Pobil. "Facial recognition patterns of children and adults looking at robotic faces." *International Journal of Advanced Robotic Systems* 9.28 (2012): 1-8.

Robins, B., Dautenhahn, K. & Dickerson, P., 2012. Embodiment and Cognitive Learning – Can a Humanoid Robot Help Children with Autism to Learn about Tactile Social Behaviour? In *Social Robotics*. ICSR12 - International Conference on Social Robotics. Chengdu, China: Springer, pp. 66–75.

Robins, Ben, et al. "Robotic assistants in therapy and education of children with autism: can a small humanoid robot help encourage social interaction skills?" *Universal Access in the Information Society* 4.2 (2005): 105-120.

Standen P, Brown DJ, Hedgecock J. et al., "Adapting a humanoid robot for use with children with profound and multiple disabilities". *in Proceedings of the 10th international conference on disability, virtual reality and associated technologies (ICDVRAT 2014)*. ICDVRAT. University of Reading, 2014. 205-211

Wainer J, Ferrari E, Dautenhahn K, Robins B. (2010). The effectiveness of using a robotics class to foster collaboration among groups of children with autism in an exploratory study. Personal Ubiquitous Computing. 4, 445–455.

Wainer, Joshua, et al. "The effectiveness of using a robotics class to foster collaboration among groups of children with autism in an exploratory study." *Personal and Ubiquitous Computing* 14.5 (2010): 445-455.

Werry, Iain, and Kerstin Dautenhahn. "Applying mobile robot technology to the rehabilitation of autistic children." *In: Procs SIRS99, 7th Symp on Intelligent Robotic Systems*. 1999.

Further – Table 4

[14] http://www.arduino.cc/en/Guide/Robot, accessed 10/04/2015
[15] https://aseba.wikidot.com/en:thymio, accessed 10/04/2015
[16] http://www.festo-didactic.com/int-en/learning-systems/education-and-research-robots-robotino/, accessed 10/04/2015
[17] http://www.lego.com/en-us/mindstorms/products/31313-mindstorms-ev3, accessed 10/04/2015
[18] http://www.robotis.us/play/, accessed 10/04/2015
[19] http://www.fischertechnik.de/en/desktopdefault.aspx/tabid-21/39_read-309/usetemplate-2_column_pano/, accessed 10/04/2015
[20] http://engino.com/robotics.html, accessed 10/04/2015
[21] https://www.aldebaran.com/en/humanoid-robot/nao-robot, accessed 10/04/2015
[22] http://www.robotis.com/xe/BIOLOID_Premium_en, accessed 10/04/2015
[23] http://support.robotis.com/en/product/darwin-op.htm, accessed 10/04/2015
[24] http://www.robokindrobots.com/zeno-r25/ , accessed 10/04/2015

Appendix A - EDUROB SURVEY QUESTIONNAIRE

EDUROB: Educational Robotics for Students with Learning Disabilities

What is the age range of the students with Special Educational Needs and Disabilities that you currently work with, or have recently worked with? Please mark an x on the relevant line below:

1-5 years ______________________
6-10 years ______________________
11-15 years ______________________
16-20 years ______________________
21-25 years ______________________
>25 ______________________

Please describe the health condition of the students you work with by marking and x on the relevant line(s) below:

Intellectual Disability ____
Pervasive Development Disorder (e.g. Autism, Asperger's, Rett) _________________
Sensory Impairment ____
Motor Impairment ____
Learning Difficulties (e.g. Dyslexia) ______________________________________
Other ____

What levels of support do your students require for the following Activities & Participation? (In each cell of the table please put the approximate number of students you work with requiring this level of support from the total number of students you work with)

	On their Own	With minimal help	With considerable help	Not at all
Learning and Applying Knowledge				
General Tasks and Demands				
Communication				
Mobility				

Self-Care				
Domestic Life				
Interpersonal Interactions and Relationships				
Major Life Areas				

What are your students' learning and developmental requirements? (mark with an x the categories that correspond to your students)

	Qualities and skills	
A	**Educational level**	
1	Perception	
2	Memory	
3	Thinking strategies	
4	Executive functions	
5	Communication skills	
6	General knowledge	
7	Detailed knowledge	
8	Basic Key competences: reading, writing, calculation, ICT	
B	**Social level**	
1	Social learning	
2	Theory of mind	
3	Task management skills	
4	Accuracy and precision	
5	Conscientiousness and sense of duty	
6	Self-presentation skills	
7	Knowing one's own pros and cons	
8	Mental persistence	

What are the preferred teaching strategies of educators when working with students with special educational needs and disabilities for meeting the required learning and developmental requirements (please tick the most relevant one for each quality and skill in the table below).

Qualities and skills	Activity based teaching	Learning through discovery	Modelling	Collaborative Learning	Instructional	Other? (Please state)
Educational level						
Perception						
Memory						
Thinking strategies						
Executive functions						
Communication skills						
General knowledge						
Detailed knowledge						
Basic Key competences: reading, writing, calculation, ICT						
Social level						
Social learning						
Theory of mind						
Task management skills						
Accuracy and precision						
Conscientiousness and sense of duty						
Self-presentation skills						
Knowing one's own pros and cons						
Mental persistence						

Which of the learning and developmental requirements in Qs. 4 and 5 do you find most difficult to meet with current teaching strategies? (please rank the 3 most difficult to meet using 1=most difficult, 2=next most difficult, and 3=third most difficult in section A and B)

	Qualities and skills	
A	**Educational level**	**Rank (1-3)**
1	Perception	
2	Memory	
3	Thinking strategies	
4	Executive functions	
5	Communication skills	
6	General knowledge	
7	Detailed knowledge	
8	Basic Key competences: reading, writing, calculation, ICT	
B	**Social level**	**Rank (1-3)**
1	Social learning	
2	Theory of mind	
3	Task management skills	
4	Accuracy and precision	
5	Conscientiousness and sense of duty	
6	Self-presentation skills	
7	Knowing one’s own pros and cons	

8	Mental Persistence	

Please identify where you think educational technology, and **robotics** in particular, can help you meet the learning and developmental requirements of your students you have identified earlier in this survey.

	Qualities and skills	**Educational Technology (identify uses in the rows below from examples including interactive whiteboards, mobiles, iPads, games, virtual worlds, simulations, blogs, other)**	**Robots (please identify briefly how robots could meet these learning and developmental needs)**
A	**Educational level**		
1	Perception		
2	Memory		
3	Thinking strategies		
4	Executive functions		
5	Communication skills		
6	General knowledge		
7	Detailed knowledge		
8	Basic Key competences: reading, writing, calculation, ICT		
B	**Social level**		
1	Social learning		
2	Theory of mind		
3	Task management skills		
4	Accuracy and precision		
5	Conscientiousness and sense of duty		

6	Self-presentation skills		
7	Knowing one's own pros and cons		
8	Mental persistence		

What aspects of your organisation might support the use of robots in the classroom? Please indicate what level of support might be provided by each of the following aspects with a rating of 1- 5 (1 = No support to 5 = High level of support)?

	Aspects	**Support Rating (1 to 5)**
A	**Organizational Aspects**	
1	Your organizational culture	
2	Staff willingness to use new methods	
3	Technical support for the new technologies	
4	Openness to inclusion of new methods in the school curriculum and IETP (Individual Educational and Training Plans)	
B	**Technological Aspects**	
1	The level of staff experience in using new technological tools	
2	The level of school provision of high-tech equipment (e.g., tablets and laptops) that would allow the control of robots in the classroom	
3	The level of staff competence	
4	The level of technical support for the use of high tech equipment within your school environment	

Please provide any other comments that you think might be helpful in terms of using robots to help your students meet their learning and developmental requirements

e.g. problems experienced; current challenges not overcome with current strategies; financial obstacles;

About You

What age range are you within? (Below 25 years, 25-35 years, 36-45 years, 46-55 years, 56-65 years, Above 65 years) ___________________

Are you male or female? ___________________

How long have you been teaching in SEN? (0-5 years, 6-15 years, 16-25 years, 26 and more years) ____________________________

How familiar are you with educational technology (please rate your skills regarding the use of the most common technological teaching tools, e.g., interactive whiteboards, iPads, mobiles, games, virtual worlds, simulations, e-portfolios, etc, from the following levels:
[None (Have never used any educational technology), Low, Fair, Good, High (confident in using a wide range of education technology)]____

Thank you very much for completing this survey. If you would like to keep up to date with the project, or receive any more information please go to http://edurob.eu/
If you would be interested in participating in piloting of the developed resources please do not hesitate to contact andy.burton@ntu.ac.uk .
Or add your email address here: ____

Please return this survey to: andy.burton@ntu.ac.uk or printed surveys may be returned to:
Andy Burton, RFB102, Clifton Campus, Nottingham Trent University, Clifton Road, Nottingham NG11 8NS.

Appendix B - EDUROB Coding sheet to be used for all literature reviewed.

Name and Organisation of Reviewer:

Paper title:

Author:

Author background:

Type of paper (study, discussion paper, product description, literature review, etc.):

Target group:

Barriers to use identified in the paper (organisational, technological, educational, social):

Study type (single case study, uncontrolled cohort, controlled cohort), learning objectives, outcome measures and conclusions, did authors rely on any pedagogical theory, criticisms of the paper (e.g., cohort too small, paper written by a manufacturer?):

Findings of the paper related to the specific questions of our literature review:

Present and future trends for technology identified by paper	
What types of students are robots currently used for in this paper?	
What Learning Objectives are robots used for in Special education in this paper?	
Is the use of robots in special education driven by any pedagogical theory in this paper?	
Are any barriers identified to the use of robots in special education in this paper?	
Has the study in this paper been objectively evaluated?	
Are there any other observations you would like to make about this paper and its findings/results?	