Educational and Pedagogic Framework

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

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Contents

1 Why we need a Pedagogic Framework

The introduction of robotics into education holds great potential for a wide variety of learners. However, teaching with robots is a new approach for teachers of children with special needs. Employing robots will be a challenge as teachers will have had no opportunity during their training to consider how they might use robots to enhance and support their teaching. It is also highly unlikely that they will have had any experience of working with robots during their career as a teacher. Introducing robots could involve a qualitative change in the underlying pedagogy on which their teaching approaches are built. For this reason, the EduRob project started by collecting views from as wide a variety as possible of teachers in special schools or main stream schools which include learners with special needs, to ensure that a pedagogical framework could be developed from their current needs and level of experience.

The role of the educational and pedagogical framework is to highlight pedagogical principles of learning with robots and to provide teachers with guidance on how to employ robots to enhance their teaching taking account of associated teaching challenges as well as what they already teach and the flexible needs of both the classroom and diverse student cohort.

Teachers do not follow a set of rigid instructions so we do not intend to be entirely proscriptive. EDUROB does provide a set of worked through examples of how to employ robots to meet students' learning needs in the context of some generic curriculum. The curriculum document D3.4 gives worked examples so that teachers can plan how to use the robots for their particular learners within their particular context. In this way, they can make use of the provided worked examples to create customized learning scenarios for their learners. In devising our example learning scenarios, we have tried to use principles that transcend the current state of technology as it is constantly changing but to also embrace the diversity of learners and differing countries' national and local curricula.

However, in order to meet the varied needs of their learners and the context in which they work, the pedagogical framework is designed to provide teachers with a set of pedagogical principles that allow them to make decisions about exactly how to use robots in order to maximise the effectiveness of employing them in the classroom. These principles can help the teacher choose the scenarios but can also help them decide when they might need to abandon one or modify its implementation.

Several activities of the EduRob project were designed to contribute to the framework. It has been informed by an extensive review of the literature and the results from a survey of teachers, in D2.2 the Student Requirements Report and D2.3 the Technical requirements Report, interviews with teachers (D3.2, the Pedagogy Requirements Report) and the results of pilot studies (D4.3 Learning with robotics cases' analysis Report).

2 Pedagogical principles relevant to Learning with Robotics

Our review of the literature identified four separate principles in developmental psychology that explain the advantages of introducing robots when teaching learners with special needs. These are the role of engagement in learning, zones of proximal flow, mediated learning and social interaction.

2.1 Engagement

According to Iovannone *et al*. (2003) engagement is “the single best predictor” of learning for children with intellectual disabilities. Discussing children with complex needs, Carpenter (2011) writes that “Sustainable learning can occur only when there is meaningful engagement. The process of engagement is a journey which connects a child and their environment (including people, ideas, materials and concepts) to enable learning and achievement”. Research has shown that learners with intellectual disabilities have higher levels of engagement when working with a humanoid robot (Hedgecock et al 2014) and this has been our experience in EduRob. Engagement was often found to be higher with the robot but this depended on what learning objectives were being worked on. EduRob pilot activity indicated that initial reactions of learners were not always positive. Some learners were initially avoidant showing signs of fear and even trying to escape from the situation. Some showed interest in the teacher but spent more time in contact with the teacher while some had a high level of interest from the beginning. However, with further carefully managed exposure those who were initially fearful became more at ease eventually working happily with the robot. So when deciding on whether to employ a robot as well as the particular way it is employed, careful introduction is needed and optimising engagement is the goal to aim for.

2.2 Zones of proximal flow.

Closely related to the idea of engagement is the notion of Flow (Csikszentmihalyi, 1997). This describes the state where the learner is in a completely motivated and engaged state when their current skills allow them to easily manage the challenges they are currently facing. The zones of proximal flow theory explains the importance of matching a learner’s current level of skill with an appropriate level of challenge. The message here for teachers is that at any given stage of learning, the learner would be comfortable (in a state of Flow) performing some tasks unaided. However, in order to progress to tasks of increasing complexity, the teacher has to assist them using scaffolding such as guidance or demonstration.

2.3 Mediated learning

According to Presseisen and Kozulin, (1992) Mediated Learning is the subtle, social interaction between the teacher and the learner in the enrichment of the student's learning experience.

As an example they describe how the child learns about harmful stimuli not through direct exposure to them but through a complex process of mediated learning, with the mother or another caretaker indicating to the child which objects are dangerous. Sometimes, the caretaker deliberately exposes a child to a dangerous or unpleasant stimulus under controlled conditions, creating the equivalent of a psychological "vaccination." The caretaker uses this opportunity to explain to the child the meaning of dangerous situations. The caretaker then uses other slightly different situations to encourage generalisation, so that the child develops an understanding of a dangerous situation and a possible response to it. They see the role of mediated learning as focussing not so much on “mastering specific bits of here-and-now data” but on “going beyond the information given, with connecting the present with both the past and the anticipation of the future”.

The mediating agent could be a parent, teacher, sibling, or “other intentioned person in the life of the learner”. However, it could also be the tools in the mediated activity and for today’s teachers, technology such as mobile devices and robots, accounts for much that is within their toolbox. In conclusion, EDUROB does not propose that the robot takes over the role of mediator from a human teacher but *complements* it. As an example, teachers can use the robot to provide prompts or cues to help the learner solve a problem. Observations from EduRob indicate that in the majority of cases there was a reduced need for teacher help and assistance when working with the robot.

2.4 Social interaction

Mediated learning presupposes the existence of social interaction between the learner and teacher or a more capable peer. In this interaction, the teacher can provide an inexperienced learner with “scaffolding” in the form of support, self-help manuals or being presented with a simpler version of the task in question. As the learner becomes familiar with elements of the task the scaffolding or training support is removed little by little. Finally, when the task is completely learned, all scaffolding will have been removed and the learner is doing the job without assistance.

For learners with special needs there are two potential barriers in making the best use of these social interactions. First, Bruner and others (eg Wood et al, 1976) argued that aspects of cognitive performance are facilitated by language. However for preverbal or nonverbal learners, teachers need to be more resourceful. Bruner also identified additional important social devices including joint attention, mutual gaze, and turn-taking in supporting learning. Here, the robot may be a useful tool when, for example, the teacher could support their verbal communication with a nonverbal learner using the robot to demonstrate a possibility by making the robot do the task first.

Second, some children, especially those with autistic tendencies, need considerable support to establish the social interactions necessary for this learning to take place. Research on using robots with children with autism (eg Wainer et al, 2014) indicates that the robots have a facilitative effect on social interaction and collaboration with others. Feil-Seifer and Mataric (2008, p1) described the effect of the robot as a “catalyst” for social interaction. This beneficial effect of prolonged exposure to a robot on autistic children’s social skills has led to the description of the role of the robot as “a mediator” between the child and others (Robins et al., 2005). Teachers should exploit this ability of robots to not only support the child's learning but to also promote social interactions between teacher and learner and between the learner and their peers. This could be particularly useful when the teacher is working with a group of learners with special needs or where the teacher is responsible for a mainstream class which includes learners with special needs.

3 How to use the EduRob pedagogical framework

With the introduction of managed learning environments and mobile learning into education, other authors have proposed helpful pedagogical frameworks (Minocha, 2009; Vavoula and Sharples (2009) Kearney et al (2012), Danaher, Gururajan, and Hafeez-Baig (2009), Parsons, Ryu, and Cranshaw (2007).

In a previous project (ViPi – http://www.edurob.eu), the pedagogic framework was developed based on the four dimensions proposed by Minocha (2009). These were Educational, Organisational, Social and Technological. They were originally developed by Minocha when examining the effective use of social software in further and higher education to support student learning and engagement. In EduRob, the influence of these dimensions can be seen in D3.4. For example, the Educational dimension encompasses the factors that are most directly concerned with the individual's learning, such as what are their learning goals and what have they achieved so far. D3.4 is structured so that, having identified the learning needs of the student including their level of capability, the teacher can match these needs to the appropriate learning areas that are given as examples. The technological aspect is also broached thoroughly in D3.4 giving sets of tools and instruction including quick guides and a full trainer's handbook to enable robot technologies to be implemented with minimal hindrance from technical aspects.

Organisational aspects have been addressed in Edurob by designing support for both high end and low end robotic platforms. Where organisational funding is an issue the cheaper tools can be implemented. The size of class and number of teachers may also affect the organisational use of the Edurob tools. Our pilot work showed that one to one, repeated sessions with each student with intellectual disabilities were more useful than working with the whole class at the same time. This was because the diverse needs of the group caused the activities to be less focussed on the abilities of each individual student; students were less distracted in individual session; background noise was reduced making it easier to hear and understand the voice initiated by the robot. However, individual sessions are not always easy for a teacher to organise so the example learning scenarios have been developed to allow flexible use and wider group and classroom scenarios can be achieved with the materials, as has been demonstrated in the pilot phase.

Our research and review of the literature suggests that, in order to get the most out of the EduRob curriculum (D3.4), activities should be carefully prepared as the robot is most effective in highly structured settings. As highlighted by Minocha (2009) lack of technical experience and support can be a barrier to successful implementation, and for this preparation is key. Before introducing the robot to students, trainers should ensure they are familiar with the technical aspects involved in each learning scenario developed and test the technological functionality of whatever robot they are using. This will ensure the sessions run smoothly and the robot responds appropriately thus facilitating the students' acquisition of learning goals. The guides provided by the Edurob consortium are comprehensive, but the nature of the technology is that there are many factors which could cause the Learning Scenario to cease to function as the trainer would want. The trainer should be prepared for this eventuality and have back up materials to use.

Results from the pilot work showed that some students with sensory integration disorders did not want to cooperate with the NAO robot because they found some of its auditory qualities aversive (for example, voice modulation, diodes and sharp, rushing movements). Some autistic students also disliked the sound of the LEGO robot motor. For these students, the robot will need to be introduced gradually and sometimes the robot will simply not be accepted. The trainer should be prepared for this eventuality and have back up materials to use. Again backup materials being available is always a sensible plan.

In order to prepare robot assisted teaching sessions, the four pedagogical principles described above need to be considered before looking at the curriculum but also all the time the curriculum is being implemented.

To summarise the principles the importance of **social interaction** emphasises the role of the teacher in learning with robots. The teacher's role is to provide scaffolding to enable the learner to tackle challenges that are currently outside their repertoire but in their zone of proximal development and to judge when to gradually remove that scaffolding. Robots could have a role in providing scaffolding by giving prompts or even a full demonstration of a task to illustrate what is required. **Mediated learning** presupposes the existence of social interaction between the learner and teacher or a more capable peer. We are not advocating that robots replace teachers in this role but support the teacher as a tool in their toolbox of technical and non-technical items such as videos, books, whiteboards or mobile devices.

In choosing the appropriate tool from the toolbox and how to employ the tool, the teacher has to consider the learner's level of **engagement** which is fundamental to learning. Robots have been found to be engaging and the teacher's role is to choose robot teaching scenarios that maintain the optimal level of engagement. Engagement needs to be maintained in order for teaching sessions to be effective. If the teacher is aware that engagement is waning, they need to investigate why and take remedial action such as changing the level of difficulty of the task. However, the teacher must also challenge the learner in order to facilitate their development and this is done by keeping them in the **zone of proximal flow**. This is when the teacher has to set a level of challenge which, given the learner's current level of skill and the teacher's assistance, enables the learner to comfortably operate at a higher level.

Teachers constantly need to adjust their activities, often from moment to moment. It is hoped that this framework enables teachers to flexibly use the Edurob curriculum in this way.

4. Putting it into Practice

Curriculum Requirements from the Pedagogy Requirements Research

In the EDUROB project application, the use of robots with our target groups in acquiring a range of social, communicational and work-related skills was envisaged.

Pedagogy requirements arising from interviews and focus groups exploring the potential use of robotics within current teaching practice gained data regarding the potential use of a robot in teaching students with learning disabilities. This theme examines current practice in teaching across countries and suggests that a range of learning outcomes is required that are scalable due to the heterogeneous nature of the target population, and that maintaining engagement is a vital success measure employed by teachers.

Other curriculum related requirements that have emerged from the interviews include that a robot-based pedagogy must:

- Allow for a wide range of learning outcomes that are required for the student cohort.
- Maintain engagement in target students.
- Consist of activities which are customisable by age, SEN and difficulty required.
- Be able to "plug-in" to existing curriculum as well as provide quick informal sessions
- Encourage interaction through a variety of tactile, verbal and visual stimuli.

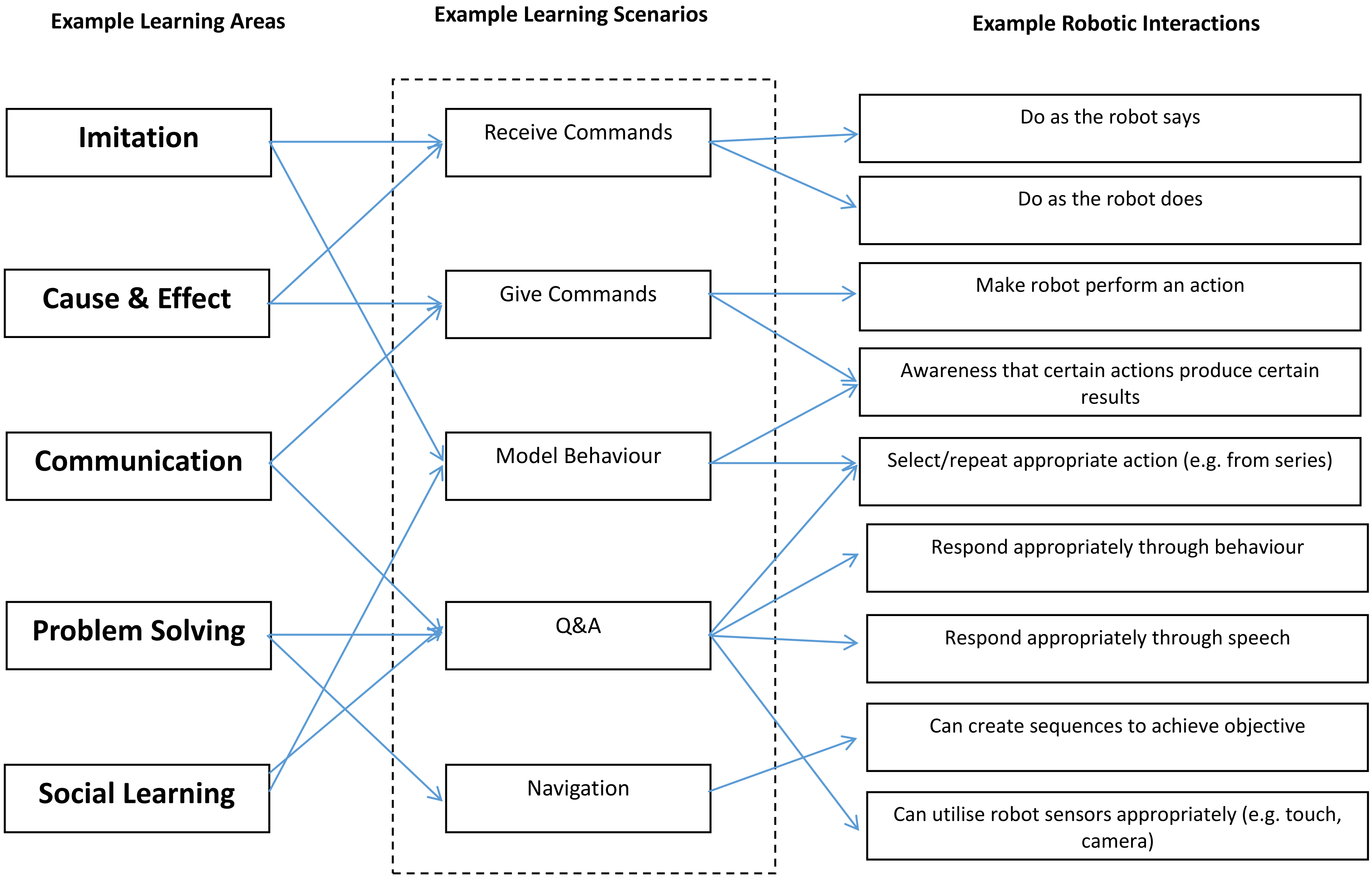
One of the interesting requirements here would be the ability to plug-in to existing curricula used in special education across the partner countries, where teachers adapt the learning scenario examples to produce a personalised curriculum to cope with the large within group variations in skills and capabilities (e.g., Using P Scales in the UK, that of the Ministry of Education Directorate of Special Education in Turkey etc).

Flexible and scalable learning outcomes (LOs) should be provided under the 5 learning areas identified in the interviews with a series of associated tasks that enable these LO's to be reached. This method will allow for a "plug and play" approach to be achieved that is adaptable to fixed curriculum and also to less formal teaching sessions. In order to determine the way in which robots could be introduced to the classroom in terms of pre-determined tasks and their intended learning outcomes, the NAO robot was first demonstrated to participants (SEN teachers), who then gave examples of potential tasks that could be achieved. From these example tasks a range of learning scenarios were identified that cover the potential learning requirements of participants within this project. In summary these following **'Learning Areas'** were identified across the partner countries:

1. Imitation – reinforcing behaviour.
2. Cause and Effect – associating action with behaviour.
3. Problem solving – through spatial reasoning, coordination.
4. Communication – improving speaking and listening through robot interaction.
5. Social Learning – how to act, appropriate behaviour.

These key learning areas can be used to classify the capabilities and therefore the learning objectives of a student within this project but can also be utilised to develop a range of potential scenarios for robotic implementation, derived across the partner countries based on the needs and requirements of the curriculum in question. These learning areas in tandem with the example scenarios to develop a range of key robotic interactions which distil any potential activity into the base behaviours available the intention of which is to provide a framework for developing further learning scenarios and a method of adaption to curriculum based teaching activities across the diverse needs found in this project. An overview of this process is provided in the mapping figure found on the following page. To summarise the approach:

- Interviews with key stakeholders found the requirements for adapting robotics to curriculum across partner countries.
- These interviews also highlighted some example robotic scenarios which were commonly reported across partners.
- These common scenarios were used to derive both learning areas that the robots can be used within and core robotic interactions that can be used to develop other robotic learning scenarios. These generic **'robotic interactions'** are as follows:
    - Make the Robot perform an action with speech RI 1
    - Make the Robot perform an action with button press RI 2
    - Make the Robot perform a certain action from a range of options RI 3
    - Recognise Robot actions RI 4
    - Do as the Robot says RI 5
    - Do as the Robot does RI 6
    - Copy a sequence of robot actions RI 7
    - Follow a sequence of spoken robot instructions RI 8
    - Respond Appropriately through behaviour RI 9
    - Respond Appropriately through Speech RI 10
    - Can create sequences of input to achieve an objective RI 11
    - Can utilise robotic sensors appropriately (e.g. touch, camera) RI 12


Example Learning Areas
Example Learning Scenarios
Example Robotic Interactions
Imitation
Cause & Effect
Communication
Problem Solving
Social Learning
Receive Commands
Give Commands
Model Behaviour
Q&A
Navigation
Do as the robot says
Do as the robot does
Make robot perform an action
Awareness that certain actions produce certain results
Select/repeat appropriate action (e.g. from series)
Respond appropriately through behaviour
Respond appropriately through speech
Can create sequences to achieve objective
Can utilise robot sensors appropriately (e.g. touch, camera)

These base robotic interactions provide the core building blocks for creating further robotic learning scenarios that fit within one or many of the pre-defined learning areas also developed from the stakeholder interviews. In total, 22 example learning scenarios were proposed by partners based on these learning areas and robotic interactions which can be "plugged" into existing partner countries curricula based on the specific needs of learners present within each. This collated list of learning scenarios can be found within the Example Learning Scenarios section of the curriculum document.

Each learning scenario, as described in the curriculum, outlines the way in which the robots proposed for use in this project may be implemented in the classroom for teaching. To this end the sequence of robot interactions that are required to achieve a certain learning objective are outlined. These form exemplar specific robotic learning scenarios that can be adapted and utilised to the specific requirements of curricula and to specific learners within the project and beyond.

Edurob has attempted to enable trainers to adapt and create new learning scenarios to extend the available set of Example Learning Scenarios in the Edurob curriculum. This has been done by using a modular and open source development strategy. Edurob has encouraged involved trainers to be hands on with adaptation of robot scenarios, by the provision of instructional sets on use of both Edurob and proprietary software within the Edurob Trainer's Guide (D3.5.04). Partners are also applying for bids to engage in follow on development and testing work themselves to exploit the project work further, which will also likely extend the database of currently developed example learning scenarios.

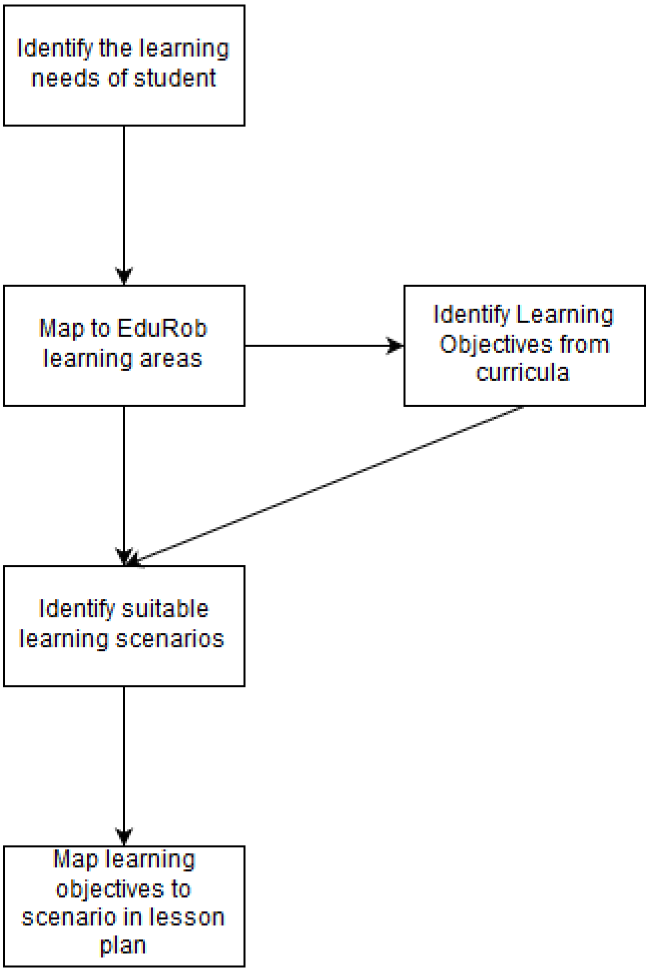
Mapping to Partner Curricula

While the learning scenarios described in the appendices provide an overview of examples of implementation - they do not demonstrate adaptation to the curriculum needs across a diverse target audience. Given the unique demands found across teaching institutions a specific outline of a robotic curriculum is impractical. Instead, this document seeks to provide a methodology to adaption that utilises the robotic learning scenarios derived from the key stakeholder surveys and interviews.

This methodology can be described in the following steps:

- Identify the learning needs of the student including their level of capability.
- Match these needs to an appropriate learning area.
- Identify the learning objectives to be achieved within the appropriate curriculum.
- Identify the potential learning scenarios derived from that robotic learning area that allows the learning objective to be achieved.
- Map the curriculum requirements to the learning scenario (i.e. if necessary customise learning scenario elements to meet learning requirements).
- Utilise within a standardised lesson plan for implementation into everyday teaching activity.

This can be outlined as the following figure:



Example Implementation of Approach

Special education within the UK utilises "P-scales" (UK Department for Education, 2014) which supplement the national curriculum by specifying performance attainment targets and performance descriptors for pupils aged 5-16 with special educational needs (SEN) who 'cannot access' the national curriculum. Please see the document reference below for more complete guidance.

In the first step of the proposed methodology, P-scales may be utilised by teachers to gauge the capabilities and learning needs of a student in a particular national curriculum subject. For example, a student identified as working towards P-scale 4 in physical education ("Pupils' movement patterns are established and they perform single actions") would have the following learning objective:

- Respond to simple commands

This would appear to map well to the imitation learning areas identified through stakeholder interviews allowing for robotic learning scenarios dealing with imitation to be examined for suitability within a standard lesson plan and teaching activity. A full set of P-Scale mapping can be found in Appendix 2, and also each Example Learning Scenario given in this document is mapped against a set of specific p-scale criteria it may help a student to achieve.

<table>
<tr><td colspan="6">Context & Profile</td></tr>
<tr><td>Author:

THR</td><td colspan="2">Title:

Practise movements when commanded to do so.</td><td>Timescale:

20 Minutes</td><td>Year group:

10-11</td><td>No in group:

One</td></tr>
<tr><td colspan="6">Relevant contextual information on learners:

Multiple and profound disabilities. Aims to successfully perform physical movement with purpose and under direction.</td></tr>
<tr><td colspan="2">How does this lesson fit into the subject curriculum or the wider curriculum?</td><td colspan="4">Prior learning of learners</td></tr>
<tr><td colspan="2">Main subject area:

Physical Education

Wider Curriculum:

Addressing and working toward P-Level 4.</td><td colspan="4">Has interacted with the robots before and is familiar with the activity.

Focus in the past was on motor movement of the upper body.</td></tr>
<tr><td colspan="6">The Learning</td></tr>
<tr><td>Groups</td><td>Intended progress (Learning Objectives)</td><td colspan="2">How will this progress be demonstrated?</td><td colspan="2">Assessment of progress by…</td></tr>
<tr><td>N/A</td><td>Successfully imitate the movement of the robot.

Repeat imitation under instruction to demonstrate reinforcement</td><td colspan="2">Imitate movement when commanded to do so with repetition.</td><td colspan="2">Teacher</td></tr>
<tr><td colspan="6">Organisation</td></tr>
<tr><td colspan="3">Resources:

NAO robot

Robot Control Application on Android device

Robotic Interaction: RI 6 – Gross Motor Imitation

Example Learning Scenario ELS 4 – Gross Motor Imitation</td><td colspan="3">Learners:

Individual learner with multiple and profound disabilities.</td></tr>
</table>

Timings	Content		
To start with…		**Cognitive / Behavioural**	**Learning scenario***
5Mins	Robot Set-up and demonstration by teacher	B	ELS 4
Main learning			
10Mins	Robotic Activity: robot demonstrates movement to be imitated and the student imitates – Focus on lower body movement (sit down, stand-up etc). Successful imitation will elicit reward behaviour from the robot. This is to be repeated until imitation upon command is clearly demonstrated by the student.	B	ELS 4
Plenary / extension			
5Mins	End of session: Check learner fatigue. Elicit final reward behaviours prior to concluding session. Initiate appropriate robot behaviour to finish prior to packing up the robot (e.g. wave goodbye).	B/C	ELS 4

A number of potential scenarios may be appropriate for encouraging imitation and choice would ultimately depend on the learning objectives to be achieved. Given the example here deals with physical education, learning scenario ELS04 (see following section), Gross Motor Imitation, may be appropriate for utilisation within a teaching session. Therefore, the following lesson plan may be derived in conjunction with the learning scenario outline found ELS04:

*Learning Scenario key: FG – Full group, SG – Small group (including partners), I – Individually

*Cognitive/Behavioural Key: C – Cognitive; B – Behavioural

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