

Learning with Robotics Curriculum and Learning Scenarios

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

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**Definition:**

This document consists of a set of the curriculum and learning scenarios based on the EDUROB pedagogy, interviews and survey carried out with stakeholders. It is expected that the content of the learning objects for the scenarios will be scoped by the user groups in each partner country. The first task is the mapping of learning areas identified in the interviews with teachers as being suitable for use with robots to established national for special education needs in each of the partner countries. The Learning Scenarios will be used in combination with the Customised Interface for Robotic Driven Interaction Model (D3.5).

**Curriculum Requirements from D3.2 Pedagogy Requirements:**

In the EDUROB 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 range of learning outcomes that are required for the student cohort.
* Maintain engagement across all ranges of ability.
* 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 stimuli.

One of the interesting requirements here would be ability to plug-in to existing curricula across the partner countries used in special education, where teachers use these to produce a personalised curriculum to cope with the large within group variations in skills and capabilities (e.g., Using P Levels 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 built in tasks that enable these LO’s to be reached. Such an approach will allow for this “plug and play” approach to be achieved that is adaptable to fixed curriculum and also less formal teaching sessions. In order to determine 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 where they then gave examples of potential tasks that could be achieved. In summary these following learning scenarios were identified across the partner countries:

INTERPROJECTS - imitation (keeping attention, observing and replicating action), action and coordination (movement, spatial orientation, having to move through a space etc.) and symbolic play (associating symbols with actions for a variety of play types). These are areas that appear consistently across all partners.

AIAS - improving spatial reasoning clarifying that it is important to teach the relationship between spatial concepts and corresponding movement, encouraging students to use such ideas to problem solve within a wider context. Understanding cause and effect can also be used as a general indicator of basic intellectual functioning. Speech therapy is suggested - “the robot could be used as a conversational partner in order to improve speech and comprehension”.

SSU - in speech therapy both in terms of talking and listening: “making sounds and words, making sentences, understanding what others say”.

The potential learning areas can therefore be summarised as follows:

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

The following were suggested from the Pedagogy Requirements document as example tasks within each of these learning areas:

**Task 1:** Receive commands **Reported by:** NTU, AIAS, INTERPROJECTS, SSU. **Description:** The robot can execute certain movements after having received instructions from the student either through speech or button presses on an input device thereby seeing the result of their actions. **Area:** Cause and Effect.
**To consider:** It is suggested by numerous partners the target audience for such task would be students with multiple and profound disabilities with low functioning cognitive ability. The aim of such a task therefore would be to maintain engagement over a session and can be easily measured for success by the number of interactions completed. The input device needs careful consideration such that it can be set-up by teachers and easily accessed by students. The relationship between the input interaction and resulting robot behaviour must also be accurate and clearly defined such that cause and effect is clearly demonstrable to the student.

**Task 2:** Give Commands.
**Reported by:** NTU, HITECO, SSU and UoC. **Description:** The robot can provide commands to the student which they have to follow (“stand-up, sit-down etc.”). Successfully carrying out the command required by the robot provides the success measure for that particular session. UoC in particular describe this as the robot stating a word, the student imitates and assessed for a match.  **Area:** Imitation, speech
**To consider:** Such tasks based on this can be broadened to a wider range of student abilities. A single command and reaction would suit those students of lower cognitive ability, however, the number of commands can be increased such that a chain of reactions must be stringed together by the student if capable. Hence, such tasks are nicely scalable as per the requirements elicited thus far in this report. In such tasks the robot very much acts as a learning mediator, with the role of the teacher being to control the robots command in a behind the curtain fashion.

**Task 3:** Physical Behaviour Modelling
**Reported by:** NTU, HITECO, AIAS, INTERPROJECTS, SSU and UoC.  **Description:** Similar to the above task but in this instance the robot mimics a behaviour to be copied by the student, thereby providing an example of how to enact certain actions.  **Area:** Imitation
**To consider:** Again, the range of and sequence of required actions could be increased for more able students. The focus again, would be on the robot being a learning mediator; however, the aim of the session may more unclear. Hence, the role of the teacher may be slightly more involved in setting up the session whereby they provide an example of what the student’s interactions should be. From then on the “behind the curtain” role can be taken up.

 **Task 4:** Question and Answer **Reported by:** NTU, HITECO, AIAS, SSU.  **Description:** The robot asks a question and the student responds either through speech or through motion. **Area:** Speech, problem solving
**To consider:** The application of such a task is well suited to a variety of curricula. The questions can be from a variety of sources; for example, asking maths questions or (as suggested by HITECO) asking students to locate body parts through either vocalising or pointing. Again, the task is well scalable given the complexity of number of questions that could be posed. There may be an additional challenge in programming the questions for the teacher which will be a barrier to overcome. Robot behaviours could be used as a reward for correct answers e.g. a dance or entertaining action so that the area of cause and effect can be promoted further.

**Task 5:** Robot Navigation
**Reported by:** NTU, HITECO, AIAS, SSU **Description:** Using simple inputs, direct the robot around a maze.  **Area:** Problem Solving
**To consider:** Primarily this task would be aimed at students of a higher ability where decision making is important. The commands to the robot must be accurate and easily accessible such that the technology enables learning and does not frustrate.

**Task 6:** Speaking Turns,
**Reported by:** NTU, HITECO, AIAS, SSU and UoC **Description:** A potential conversational exercise with the focus being on social interactions and how to react appropriately. The robot could, for example, be used to demonstrate social cues (laughter, clapping, and other emotions) and the students react/interact appropriately or be used to learn how to carry a conversation such that the content is not the focus but the protocol of conversation is learned.  **Area:** Social Learning
**To consider:** It is suggested that this would be a suitable task for high functioning students with little patience aiding them in practicing social conventions to an audience that they may be more comfortable with. Again, cues the robot can offer should be easily programmable and accessible while if the robot is expected to respond the student, the sensor must be accurate to avoid frustration.

The learning outcomes for the above tasks must adhere to the s elicited in the report. This document suggests that these learning outcomes stem from the areas of learning identified prior to the example tasks listed here. The tasks would then need to be open enough to satisfy the learning outcome from its particular area allowing for a “plug and play” style pedagogy that is quickly adaptable to the needs of the classroom.

HITECO, for example, suggests the following learning outcomes: “correctly implemented task given to student”, “speed of assimilation of new content”, “students involvement” etc.

NTU extends the argument for looking at student involvement and reiterates points made in pre-robot learning outcomes regarding engagement: “Success … for some would be to show awareness”. Furthermore, participants responded here that learned skills should be transferable to daily situations, a measure which will only become evident through long term study of the effects of a robot-based pedagogy.

Indeed, AIAS suggests learning outcomes based on improvement which requires longitudinal studies to measure: “increased vocabulary, increased eye-contact”.

**2. Process and Mapping of Learning Areas to EU wide SEN Curricula**

This section begins to describe a process whereby flexible and scalable learning outcomes (LOs) could be related to the 5 learning areas identified in the interviews in our partner countries, with a series of built in tasks that enable these LO’s to be reached. Such an approach will allow for the “plug and play” approach to be achieved that is adaptable to fixed curriculum and also less formal teaching sessions.

The methodology involved reviewing the performance attainment targets (P Scales) and performance descriptors for students aged 5-16 with special educational needs (SEN) in the UK who cannot access the National Curriculum [1]. The descriptions show the range of overall performance that pupils might demonstrate. P scale descriptors P4 to P8 describe pupils’ performance in a way that indicates the emergence of skills, knowledge and understanding, and are characteristic of the types of attainment that learners with special educational needs are likely to demonstrate. This process and mapping will be reviewed by the EDUROB partnership and then applied to other SEN curricula across our partnership in our partner countries to relate the identified learning areas to flexible and scalable LOs, and therefore allow plug into existing SEN curricula.

**Each student with learning difficulty in Bulgaria has appointed resource tutors/ special educators who are entitled to work with him/her extra 4 hours per week where the robot activities could be also applied.**

The initial mapping for **Imitation** would be:

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| Curriculum Area | Performance Descriptor  | Types of Attainment (as flexible and scalable LOs) | Example Robotic Mediated Tasks | **Bulgaria (mainstream schools intra and extracurricular activities)** |
| **Physical Education** | P4 Pupils’ movement patterns are established and they perform single actions  | They respond to simple commands  | The robot can provide commands, or demonstrate movements to the student which they have to follow (“stand-up, sit-down etc”) | **The students can be included in activities such as:**1. **Schools celebrations**
2. **Presentation of extracurricular activities within the school – traditional dances, lyrics, songs, performances.**
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|  | P5 Pupils link two actions in a sequence  | They recognise and collect, on request, familiar pieces of equipment  | The robot issues instructions to gather several pieces of equipment – such as a hoop and basketball | **Possible in the classes of physical activities and sport.**  |
|  | P8 Pupils move with some control and coordination | They follow and imitate sequences and patterns in their movements  | The robot increases the complexity of the movements to be imitated (e.g., stand up, turn around, and sit down). | **Possible for the classes of music and arts – dances, new song together with a dance (traditional folk dances)** |
| **Using and applying Mathematics** | P6Pupils sort objects and materials according to a given criteria  | They copy simple patterns or sequences  | The robot performs a simple pattern of repeated movements; and the student copies these movements. | **Possible for the classes of Mathematics.** **We may add additional activity for recognition of shape and volume of different geometric objects.**  |
| **Music** | P5 Pupils take part in simple musical performances | They listen to, and imitate, distinctive sounds played on a particular instrument  | The robot plays a series of distinctive sounds that the students have to imitate. | **Possible for the classes of music and arts.****Additional multitasking activity is possible such as dancing and singing in parallel together with the robot.**  |
| **Languages** | P4Pupils attempt to repeat, copy or imitate some sounds heard in the target language | They listen and may respond to familiar rhymes and songs in a foreign language.  | The robot plays familiar rhymes and songs and the students repeat, copy and imitate these sounds. Robot voice recognition could be used to check accuracy. | **Possible in classes of English language. In Bulgaria this subject is compulsory even for primary schools curricula.**  |

The initial mapping for **Cause and effect** would be:

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| Curriculum Area | Performance Descriptor  | Types of Attainment (as flexible and scalable LOs) | Example Robotic Mediated Tasks | **Bulgaria (mainstream schools intra and extracurricular activities)** |
| **Computing** | P4Pupils make selections to communicate meanings | Pupils make selections to generate familiar/preferred sounds or images. They know that certain actions produce predictable results | Pupils use a switch to activate their favourite piece of music or dance performed by the robot | **Possible for music classes and extracurricular activities**  |
| **Using and applying mathematics** | P4 Pupils are aware of cause and effects in familiar mathematical activities  | They anticipate, follow and join in familiar activities when given a contextual clue  | The robot sings a song or a rhyme. Students are challenged to anticipate the next chorus or action in these songs and rhymes.  | **Not applicable** |
| **Music** | P4 Pupils use single words, gestures, signs, objects, pictures or symbols to communicate about familiar musical activities or name familiar instruments | They are aware of cause and effect in familiar events  | The robot performs a song and dance. The student recognises that this can be started and stopped through their action – such as clapping their hands, stamping their feet, or using a switch.  | **Possible for music classes and extracurricular activities** |

The initial mapping for **Problem Solving** would be:

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| Curriculum Area | Performance Descriptor  | Types of Attainment (as flexible and scalable LOs) | Example Robotic Mediated Tasks | **Bulgaria (mainstream schools intra and extracurricular activities)** |
| **Listening**  | P5 Pupils respond appropriately to questions about familiar or immediate events or experiences  | They follow requests and instructions containing at least two key words, signs or symbols  | The robot asks a series of questions and student responds via speech  | **Applicable only for students with mild learning difficulties.** |
|  | P6 Pupils respond to others in group situations  | They follow requests and instructions with three key words, signs or symbols  | Robot asks a series of questions and student responds via speech (could also be used in Social Learning) | **Not applicable.** |
|  | P8 Pupils take part in role play with confidence | Pupils listen attentively. They respond appropriately to questions about why or how | Robot asks a series of questions and student responds via speech (could also be used in Social Learning) | **Applicable only in activities led by the resource tutor who can facilitate the learning process.** |
| **Geography** | P5 Pupils consolidate a sense of place and direction  | Pupils can follow set routes around familiar places | Pupils direct the robot around a maze to demonstrate their understanding of sense of place and direction | **Applicable only for students with mild learning difficulties.** |
| **History** | P5Pupils know they took part in past events and they listen and respond to familiar stories about their own past | With some prompting or support, they answer simple questions about historical artefacts and buildings  | The robot asks questions related to historical artefacts - for example, identifying a bowl as being made out of wood. | **Not applicable.** |
|  | P7Pupils begin to recognise some distinctions between the past and present in other people’s lives as well as their own and communicate about these in simple phrases and statements | They listen to and follow stories about people and events in the past as well as events in their own lives. They sort objects to given criteria  | The robot tells a series of historical stories. It then prompts them to sort real objects into new and old categories for example, old toys and new toys. | **Applicable only for mild learning difficulties (dyslexia, dyspraxia, dyscalculia, Asperger).**  |
| **Using and Applying Mathematics** | P5 Pupils sort or match objects or pictures by recognising similarities  | They make sets that have the same small number of objects in each  | The robot challenges the students to distribute sweets into containers so that there is one or two in each. The students sort objects into red or blue categories, and then challenge the robot to kick the red ones (using object recognition system) to gain feedback on correct selection.  | **Applicable only for mild learning difficulties (dyslexia, dyspraxia, dyscalculia, Asperger).** |
|  | P7 Pupils complete a range of classification activities using a given criterion  | They respond appropriately to key vocabulary and questions  | The robot poses questions such as, ‘How many blue balls’? And student responds. Robot uses object recognition to check answer. | **Applicable only for mild learning difficulties (dyslexia, dyspraxia, dyscalculia, Asperger).** |
| **Number**  | P5 Pupils respond to and join in with familiar number rhymes, stories, songs and games  | Pupils can indicate one or two  | Robot sings a familiar song or rhyme. Students are challenged to say (robot voice recognition), or sign (robot object recognition – e.g., for Makaton Symbol) to indicate at least one of the numbers in the song or rhyme. Other means by which the robot could recognise the answer may be through number of eye blinks, eye pointing or gesture (robot vision system). | **Possible for mathematics, music and literature classes as well as extracurricular activities on the similar subjects.**  |
|  | P6Pupils demonstrate an understanding of one-to-one correspondence in a range of contexts. Pupils join in rote counting up to five  | They count reliably to three, make sets of up to three objects and use numbers to three in familiar activities and games  | Students touching one, two, three items as the robot counts. | **Applicable only for mild learning difficulties (dyslexia, dyspraxia, dyscalculia, Asperger).** |
|  | P8 Pupils join in with rote counting to beyond 10  | They continue to rote count onwards from a given small number  | Students continue to say, sign or indicate the count aloud when the robot begins counting the first two numbers | **Not applicable** |
| **Space, Shape and Measures**  | P5 Pupils search intentionally for objects in their usual place  | They compare the overall size of one object with that of another where there is a marked difference  | Robot challenges the student to indicate which of two shoes is the bigger, compare objects – big boxes and small boxes. | **Possible in Mathematics classes as well as in Primary school subject & Kindergarten.**  |
|  | P7 Pupils respond to ‘forwards’ and ‘backwards’  |  | Robot asks to be moved forwards or backwards and students uses the interface to select the correct action. | **Not applicable.** |
| **Science** | P4 Pupils explore objects and materials provided, changing some materials by physical means and observing the outcomes  | Pupils communicate their awareness of changes in light, sound or movement.  | Students make a sound or clap when the robot begins to move or makes a sound. | **Possible in Mathematics classes, extracurricular activities as well as in Primary school subject & Kindergarten.** |
|  | P5Pupils take part in activities focused on the anticipation of and enquiry into specific environments  | They respond to simple scientific questions  | The robot poses simple scientific questions – such as show me the flower from the range of objects in front of them. The robot’s object recognition system could be used to check the answer.  | **Possible in Mathematics, Physics, Public science, Living classes, extracurricular activities as well as in Primary school subject & Kindergarten.** |

The initial mapping for **Speech** would be:

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| Curriculum Area | Performance Descriptor  | Types of Attainment (as flexible and scalable LOs) | Example Robotic Mediated Tasks | **Bulgaria (mainstream schools intra and extracurricular activities)** |
| **Speaking**  | P4 Pupils repeat, copy and imitate between 10 and 50 single words, signs or phrases or use a repertoire of objects of reference or symbols | They use single words, signs and symbols for familiar objects  | The robot speaks the word and the student responds verbally to an agreed tolerance | **Possible but decreased number of words and signs.****It needs facilitation by the teacher / resource tutor.** **Applicable for language oriented subjects (Bulgarian, English etc.), literature, mathematics, philosophy, physics, chemistry, biology, civil rights etc.)** |
|  | P5 Pupils combine two key ideas or concepts | They combine single words, signs or symbols to communicate meaning to a range of listeners  | They present two signs to the robot in a logical sequence (e.g., stand up, walk) | **Possible only for people with mild learning difficulties.**  |
|  | P7 Pupils use phrases with up to three key words, signs or symbols to communicate simple ideas, events or stories to others |  | They present two (three, four,...as a flexible, scalable LO) signs to the robot in a logical sequence (e.g., stand up, walk) | **Not applicable.** |
| **Geography**  | P5 Pupils consolidate a sense of place and direction  | They can answer simple questions about places and people  | Robot asks questions such as ‘Who can help us?’ Student must point to correct person | **Possible also for other subjects like Traffic rules (Primary school & Kindergarten) and subjects oriented to the Nature (interaction of the human and the environment).****Extracurricular activities such as emergency training and reactions upon natural disasters.**   |
| **Languages** | P5 Pupils attempt one or two words in the target language in response to cues in a song or familiar phrase |  | Robot says a familiar phrase and challenges the student to speak one of the words in the target language (using robot speech recognition system, within a range of tolerances) | **Not applicable.**  |
|  | P7 Pupils introduce themselves by name in response to a question in the target language | They listen, attend to and follow familiar interactions in the target language.  | The robot asks them to introduce themselves in a foreign language and listens for response (using robot speech recognition system, within a range of tolerances).  | **Possible for extracurricular activities (due to noise in mainstream classes) and those facilitated by the resource tutors in language,** **literature subjects however it depends on the ability of the recognition system. The process should be facilitated by the teacher / resource tutor.**  |
|  | P8 Pupils listen attentively and know that the target language conveys meaning | They respond briefly using single words, signs or symbols  | The robot asks a question in a foreign language and the students is challenged to respond using single words (also could be used in problem solving) | **Not applicable.** |

The initial mapping for **Social Learning** would be:

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| Curriculum Area | Performance Descriptor  | Types of Attainment (as flexible and scalable LOs) | Example Robotic Mediated Tasks | **Bulgaria (mainstream schools intra and extracurricular activities)** |
| **Listening**  | P8 Pupils take part in role play with confidence | Pupils listen attentively. They respond appropriately to questions about why or how | Robot initiates conversation and instructions and pupils take turns to answer | **Possible for subjects as geography, biology, literature, astronomy, physics.** **Applicable only for mild learning difficulties (dyslexia, dyspraxia, dyscalculia, Asperger).** |
| **Physical Education** | P7 Pupils express themselves through repetitive and simple sequences and movement patterns. Their control and coordination skills are developing | They share and wait their turn  | The robot performs simple series of activities and challenges students in a group situation to copy these. Students must wait their turn (also applies to Imitation).  | **Possible only in kindergarten.**  |
| **PHSE** | P4Pupils express their feelings, needs, likes and dislikes using single elements of communication (words, gestures, signs or symbols) | They show an understanding of ‘yes’ and ‘no’, and recognise and respond to animated praise or criticism.  | The robot praises the students in animated ways, and encourages students to respond appropriately. | **Need additional clarification.** |
|  | P6 Pupils respond to others in group situations, playing or working in a small group cooperatively  | They may show concern for others  | The robot displays a range of emotions and the students are encouraged to respond appropriately to distress. | **Possible only for extracurricular activities where a group can be formed.**  |

**Conclusions and next steps:**

The learning areas identified in the Pedagogical Requirements have been linked to SEN curricula in the UK. This mapping is now being extended to other EU-wide SEN curricula, to identify a wide range of flexible and scalable LOs, and hence facilitate the plug and play nature of our approach.

To facilitate these learning scenarios a range of robot functionality to be embedded in D3.5.1 - Customised interfaces for robotic driven interaction model has been identified as:

* Receive commands
* Give Commands
* Physical Behaviour Modelling
* Question and answer
* Robot Navigation
* Speaking turns

**References:**

[1] Performance - P Scale - attainment targets for pupils with special educational needs, July, 2014. https://www.gov.uk/government/uploads/system/uploads/attachment\_data/file/329911/Performance\_-\_P\_Scale\_-\_attainment\_targets\_for\_pupils\_with\_special\_educational\_needs.pdf