ADDENDUM (Toolkit)

English version

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After sharing the toolkit with the educational community, some pre and primary teachers carried out some of the activities proposed in it. Once these activities were implemented, teachers proposed possible improvements and alternatives, in which robotics and programming take on a more relevant role than was initially granted in the toolkit activities. The results of this exchange of knowledge have been compiled in this addendum that can be found in English, Spanish, Swedish, Italian and Greek.

Co-funded by the Erasmus+ Programme of the European Union

Domotic Garden

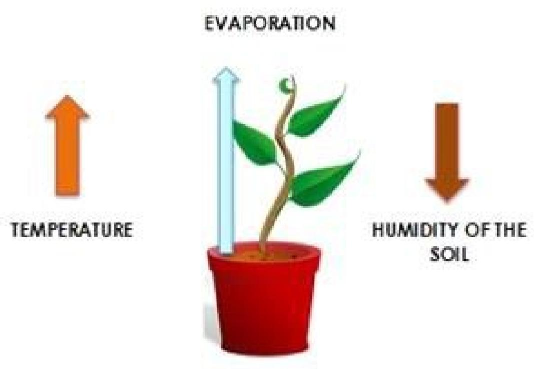
R	S	T	E	M
ROBOTICS	**THE SCIENTIFIC METHOD**	**TECNOLOGY**	**ENGINEERING**	**MATHEMATICS**
Program a watering system for your garden	Plants – Living beings	BBC Microbit	Create a watering system	Measurement units, tables, graphs

CONCISE DESCRIPTION

Nowadays, robots are part of our daily lives. Not only are they in industry but they are also in our houses and schools and they make our life easier. In this unit, kids are called to design and build a 'domotic garden' in order to grow plants in a more effectively and efficiently way. For that reason, they have to learn about what a domotic system is; how it works and how it can be programmed. In addition, they have to generate their own knowledge about plants following the Scientific Method and how to create a system capable of taking care of our garden. In order to achieve these goals, kids have to apply mathematical knowledge about measurement instruments and units, tables and graphs.

OBSERVE & QUESTION

At the beginning of the class it is important to encourage a collaborative environment where kids are able to share their opinions and doubts, where they can work together and where they can generate their own knowledge. For that, it would be a good idea to introduce the concept of Smart Garden through a piece of news or a video where they can analyze how it works and identify which are the advantages and disadvantages of its use. Boost a dialogue among the members of the class, what do you think about smart gardens? Is it useful? What for? What things/variables can be controlled in your garden with this system? How does it work? Is it related to robots?



Inspire children to talk and discuss more deeply about the variables which must be controlled in a garden such as temperature, humidity, insects, soil, etc. and focus their attention on two of them: temperature and humidity. Help them relate these concepts to their experiences through the evaporation process.

What happens to the puddles after raining when the sun shines and the temperature is high? And if there is no sun and the temperature is low?
Introduce a discussion about their experiences and ideas about temperature and evaporation, and talk about how temperature and humidity can be measured. Make sure that the students have understood these concepts properly and then show them a BBC microbit.

PLAY & DISCOVER

Let pupils investigate in groups about what a BBC microbit is, discover how it works and test it. After that, design some activities/challenges to work with this gadget having in mind their previous experiences with programming and specifically with BBC microbit. You can get ideas at: https://microbit.org/

When children feel comfortable working with BBC microbit, guide them in programming a temperature and a humidity gadget. If you consider it appropriate every group can be responsible of only one of them in order to explain to the other groups how they have managed to program it afterwards. Letting the pupils become a "teacher" helps them to consolidate their knowledge and improve their reasoning skills through giving and receiving instructions with peers.

DESIGN-EXPERIMENT-PROGRAMME

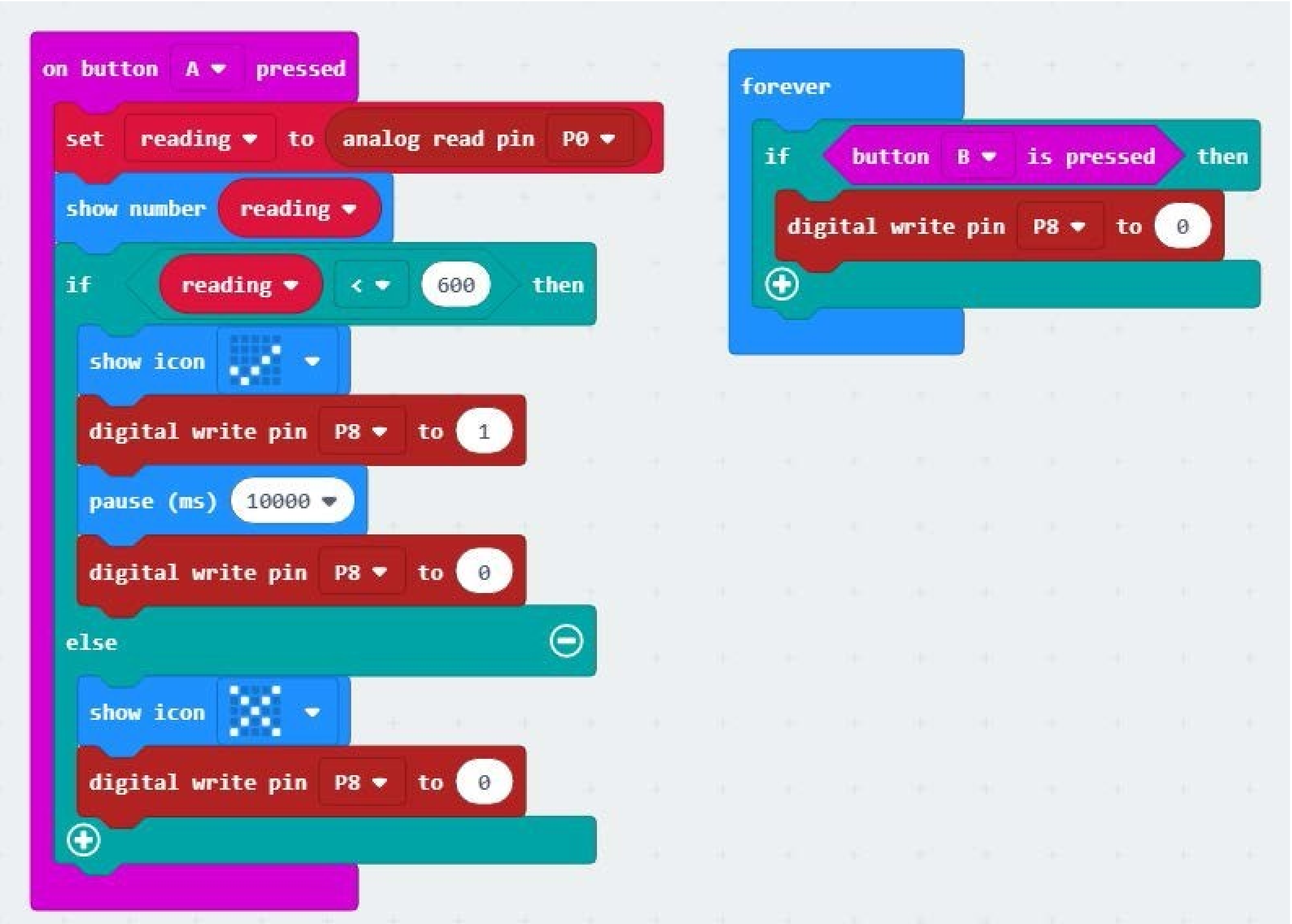
Once the BBC microbits are programmed it is time to test them. Create bigger groups getting together one which was responsible for a temperature gadget and other for a humidity one and give them two plants with very different needs, such as a cactus and basil.

Encourage children to identify what the plants need to live and use the Scientific Method for it. Firstly, provide them with resources that they can use to find out information about this topic that allows them to define the hypothesis, how much water does the cactus need to live? And the basil? Are high temperatures appropriate for the basil? And for the cactus?
After that, with your support, they must design an experiment to check what conditions of temperature and humidity that these two plants need. They must decide how much water they will use for the plants and where they will be located (both plants of each group must be under the same conditions and these conditions must be different from the rest of the groups in order to compare the results afterwards). One more option to consider is to introduce the concept of sunshine, a new variable which can be measured after programming a BBC microbit as a light sensor.

During a week they have to measure the temperature and the humidity of the plants and describe how they are (students can also take photos or draw pictures), have the plants changed their colour or their size? If it has leaves, are they fresh or dry? If it has prickles, are they sharp? Does it have any shrunken part? If you consider it appropriate you can create a poster where kids can write down their results or draw graphics and tables. This will help them compare more easily the results gathered from every group.
After a week the groups must explain their findings to the rest of the class and discuss all together the analyses, the results and draw conclusions. Do both plants need the same quantity of water? Do both plants withstand cold temperatures? What happens to basils when the temperature is high?
A wide range of options can be also included in this inquiry sequence if you consider it applicable for your pupils, such as deciduous and evergreen plants, sunshine and photosynthesis or even the evolution of the plants.

When they have defined the best conditions of temperature and humidity for the plants, each group has to choose one to take care of and design a watering system using the Engineering Design Process. Support kids to imagine possible solutions having in mind the knowledge acquired and the gadgets used before and they can analyse the ideas and suggestions proposed so as to choose the most promising one. Provide them the appropriate support to plan how they are going to create the watering system using the plants, the BBC microbit, the water sensors, the pumps and the bowls with water supply and taking into account children coding skills, help them to think and reason how to create the code asking them questions and explaining them each step. Here you have a code for your BBC microbit, but remember:

There are a lot of possibilities; this is just an option:



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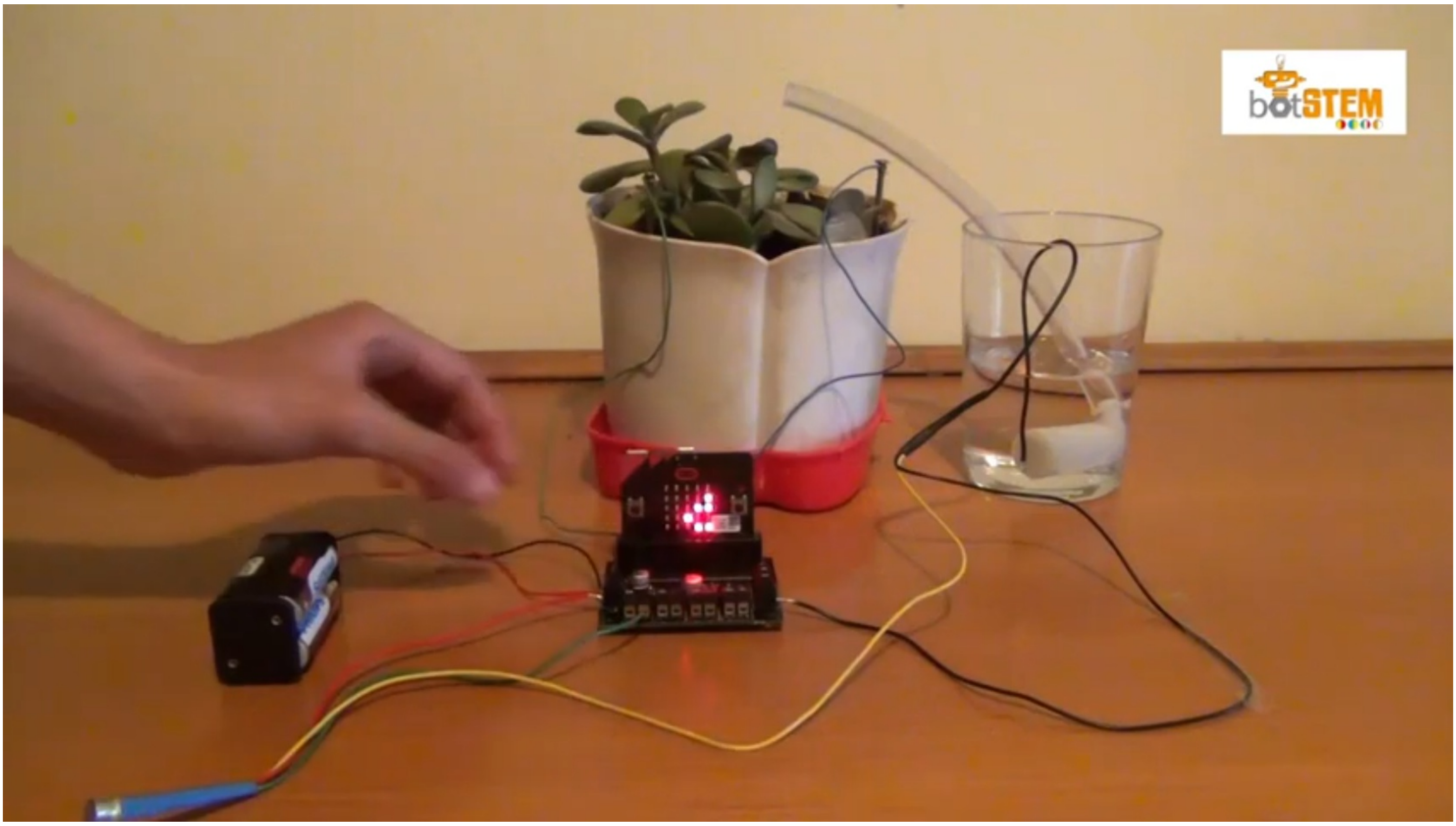
You can find some videos at:

https://www.youtube.com/watch?v=jcc5Qae2Cfs
https://www.youtube.com/watch?v=Pf3Hcaspqws

EVALUATE & SHARE

Once the watering system is ready it is time to test it and make the suitable improvements. After sharing their knowledge and the key of their prototypes, a discussion can be held, is an irrigation system useful? How it can facilitate people's life? Which other applications does it have? Do these watering systems help preserve natural resources such as water? They can also create a poster, a stop motion video or a slide-presentation that shows with photos, pictures, etc., what are the best conditions for the plant they chose, what happens to the plant when the circumstances are not the right ones and how a watering system can be created.
As a complementary activity you can explore and search what are the cares that the plants would need if they were on Mars and think about how they can grow and take care of them using robots.



Looking for metals

R	S	T	E	M
ROBOTICS	**THE SCIENTIFIC METHOD**	**TECNOLOGY**	**ENGINEERING**	**MATHEMATICS**
Program a metal detector	Magnets	Measurement instruments	Build a magnetic arm	Geometric figures, measurement units and scales

CONCISE DESCRIPTION

Learning to observe what is happening around us carefully is essential to develop environmental awareness. Children's experiences are a good starting point for analysing and thinking about nature and green zones where they live or visit, in order to notice the need to be environmentally friendly. In this unit, students are going to analyse the reality of our beaches and they will have the opportunity to develop a metal detector to help us remove magnetic objects from the sand. In order to achieve this goal, children have to learn about magnets, scales, geometry figurers and measurement units. This learning process is based on The Scientific Method and The Engineering Design Process.

OBSERVE & QUESTION

The development of an environmental awareness is essential nowadays, because of the serious damage inflicted upon woods, oceans and rainforests, due to our new ways of life. Children know of this situation, given that they see the rubbish accumulating around river banks, in woods and even on the beaches where, unfortunately, we find more than sand, living things and shells.
Firstly, generate an active dialogue where children can talk about their beach experiences, what things can we find on the beach? Do you think that some of the things that we find there shouldn't be there? Do these things have an impact on the environment? Focus their attention on metals (silver bracelets, bottle taps, cans, etc.) that can be found in these natural habitats and encourage them to design an action plan, in order to remove all of the waste, even those which are hidden in the sand. Talk about how robots can help us to solve environmental problems and draw their attention to the subject that occupies us. Children can search for information on the Internet or in other resources you consider appropriate for the pupils.

PLAY & DISCOVER

Introduce the topic of magnets and let them play and discover their properties using for example a programmable robot called 'Mio'. The children can freely discover its functions (among them its magnet arm), but they might need support to feel confident. How does it work? What can it do? How can we program or "code" it? How can it help us solve the problem? When they feel comfortable with it, distribute magnets of different powers and sizes, magnetic and non-magnetic objects, as well as, sand, boards and other suitable elements. While children are observing and experimenting, you can guide them by asking questions that direct their actions and thoughts. Do all magnets attract all objects? Are magnetic objects attracted at the same distance? What happens when there's a surface between the magnet and the object? And when the object is hidden deeply in the sand? What magnetic objects are attracted by the robot-magnet? Why do you think all magnetic objects are not attracted by the robot-magnet?

> You can also design and create a magnetic arm and join it to a simple robot.

DESIGN-EXPERIMENT-PROGRAMME

Once the children have learnt how to program the robot and run it to accomplish our objectives, they have to identify the properties of the magnets using the Scientific Method. Firstly, help them to organize all the information that they have previously observed and to define the hypothesis, what objects are attracted by the magnets? Can magnets attract objects when there is a surface between them? Do magnets have different power?

After that, with your support, each group has to design an experiment to check their hypothesis. What do you want to know? What materials do you need? What do you have to take into account? One option, in order to organize the data, would be to create worksheets adapted to the skills of the students.

When the experiments have finished, each group has to share their results and to draw relevant conclusions. It is important to reflect upon what they knew and thought before and what they now know, and to analyse what has changed, and how it has changed. Was your hypothesis correct? How have you checked the hypothesis? Have your former ideas changed after conducting the experiments?

As soon as the children know the properties of the magnets and the potential of the robot, they have to redesign the former action plan, to include the new knowledge they have learnt. At the start of the mission, the children have to choose a beach that needs to be cleaned, while doing so they can learn about geography and critically analyse why this situation has occurred.

Help them to pose questions that facilitate the design of a proper procedure to tackle the problem. What can we do to analyse the entire beach without overlooking a meter? Print a photo of the beach on a piece of paper and draw a grid on it, then you can represent that grid on the floor on a larger scale, taking into account that the size of each square must depend on the distance covered by the robot in every step. Once the grid is drawn, leave a magnetic object on a square of the map, and ask each group to draw the sequence on a piece of paper with arrows that represent the path the robot must follow, before it is programmed. Give them different challenges, in which all the magnetic properties that they have become familiar with are reviewed and gradually raise the level of difficulty. Help the children to identify and to confront their own mistakes and to develop their capacity for self-correction, and to understand that errors are part of the learning process.

Lay out potential problems that they might face and make them think, so as to find possible solutions. What are you going to do if there is a non-magnetic object? After the robot has attracted a magnetic object, what are you going to do so that it continues attracting more objects? Where are you going to leave it before picking up a new one? If you only have one rubbish bin in which to leave the objects, where are you going to place it? (Give them different possibilities). Remind them of the importance of analysing the new situation carefully and define the action plan for cleaning the beach, before programming the robot. To make this step easier, you can distribute worksheets to organize the information and to define the procedure that will be followed.

> If you want to work a little bit more on programming with your students, you can also use the Bluebot app to import a picture of a beach and program this robot on a tablet.

EVALUATE & SHARE

The relevance of the project means it has to be shared with other people. Children can create an environmental campaign to raise public awareness of the importance of this global problem with articles, advertisements, posters, and performances using different formats and tools. Of course, their creations have to include how metals can be removed from beaches and how STEM disciplines and robotics can contribute to achieve that objective.

MODIFICACTION IN PRACTICE

An alternative use of the Bluebot app could be to look for metals with a physical Bluebot, as a teacher with preschool five-year-olds has previously reported. They put a small horseshoe-formed magnet on the "nose" of the Bluebot, stuck down with adhesive, and programmed the robot to walk on a grid on the floor where different small items were placed in some of the squares. In this way, the Bluebot looked for metal things while the children and teacher discussed the children's hypotheses about what items would stick to the magnet. The questions described above could be used to direct the children's attention to the crucial features of magnets, for instance:

- What items are attracted to the magnet? What do these items have in common?
- What items are not attracted to the magnet? What do these items have in common?
- Are magnetic items attracted at the same distance?
- What happens as the robot approaches the magnetic item, or another magnet?

Using the Bluebot as a link between different aspects of a natural science phenomenon

R	S	T	E	M
ROBOTICS	**THE SCIENTIFIC METHOD**	**TECNOLOGY**	**ENGINEERING**	**MATHEMATICS**
Coding	Observation, stepwise procedure, colaboration	Bluebots	Building paths	Calculating steps and change of direction

DESIGN-EXPERIMENT-PROGRAMME

Preschool teacher X tried out the activity with four children seated on the floor around a mat with a picture representing a small town. The mat had a grid with some squares representing shops and others streets. The children had been working with stones and rocks as their natural science project and the teacher let child A place a stone on the grid and let child B program the bluebot to walk towards the stone from an optional square. The children changed roles so that everyone in the end had been both a "stone-placer" and a programmer. During the activity, the children interacted with and helped each other. The children and the teacher discussed the different steps the bluebot had to take and how to reason over the path it could follow. After this initial and common activity, the teacher gave the children a task to create their own paths/tracks for the bluebot to walk. Every child had their own bluebot and stone that they had chosen and continued the activity as a free inquiry. Two children decided to work alone, but after a while they started to interact and build an inclining plane for their two bluebots to race up.

Two other children decided to join up and together build a track with rods for their bluebots to drive between. They continued by programming the two bluebots to "crash" into each other, which took some planning, since the bluebots had to meet at a certain spot on the track at the same time. The teacher followed the activities of the children and guided them with questions and suggestions, also suggesting that the they share other ideas about problem-solving etc.

Children programming each other as Bluebots in primary school

R	S	T	E	M
ROBOTICS	THE SCIENTIFIC METHOD	TECNOLOGY	ENGINEERING	MATHEMATICS
Unplugged coding	Observation, comunication	Papers with arrows and instructions	Building paths	Calculating steps and directions

DESIGN-EXPERIMENT-PROGRAMME

In the original version of this activity, three children worked together with one as an observer, another as a programmer, and the third as the 'bluebot'. The programmer programmed the child playing the bluebot to follow a winding path of arrows on the floor, and the observer observed and evaluated the actions.

In the modifed activity, the preschool teacher simplified the arrangement by concentrating it on the path of arrows. The preschool children did not program each other but instead, one at a time, they first followed the paper arrows on the floor. The preschool teacher and the child discussed the different steps that the child had to take, as the child advanced on the path.

Another modification to the original activity that the teacher introduced was to add instructions alongside some of the arrows on the papers, inviting the children to e.g. "jump three steps forward". The teacher had also added some papers with question marks, allowing the children to choose the programming step they wished to follow for themselves. The children chose to cart wheel, jump, turn somersault and other physical activities, and the question marks quickly became the most popular instruction on the path. After all of the children had tried out the teacher's path, the teacher encouraged the children to create their own 'arrow paths' for their classmates to follow. In this process, the children collaborated and communicated and, together with the teacher, tried out their own arrangements for the sequential order of the arrows. The question mark and the children's own creation of paths added a free inquiry step and included the children's own ideas as new modifications to the original activity.

Unplugged coding

R	S	T	E	M
ROBOTICS	**THE SCIENTIFIC METHOD**	**TECNOLOGY**	**ENGINEERING**	**MATHEMATICS**
Coding without computers	Observation, compare, identify patterns, stepwise procedure	Whiteboard and pen	Create and refine your design	Logical thought

OBSERVE & QUESTION

Unplugged programming or coding is a way to learn about basic concepts and methods for programming, by means of using your own body, physical materials and the nearby surroundings. Unplugged programming is about developing an understanding of how a computer program works and how it can be constructed. There are hundreds, perhaps thousands of programming languages, but all of them are dependent on clear and unambiguous instructions. A programming language serves as a bridge between human languages and the computer. It is a language that computers can interpret, in order to implement instructions.

PLAY & DISCOVER

Some initial activities could be:

1) Let the children reflect on objects and/or events in their every-day surroundings that are controlled by programs. Let the children describe the objects/events and reflect upon why it works that way. Try to demonstrate the fact that people are responsible for all programming.
2) How many object/events do you have in the near school or pre-school context that are subject to programs.
3) Make a “programming-walk” with the children to observe objects/events where programming is involved.

DESIGN-EXPERIMENT-PROGRAMME

PROGRAMMING THE TEACHER

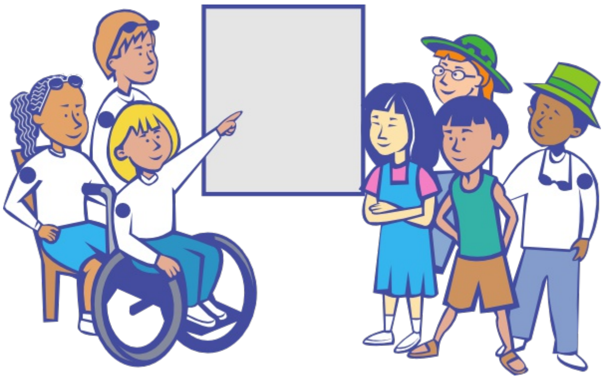
The teacher stands in front of a whiteboard. The children are instructed to direct the marker in the teacher’s hand to draw a human-like figure.

If possible, it is even more effective to let two teachers stand in front of the whiteboard with a distance that is as large as possible between them. Both teachers are directed by the same instructions. The outcome on the whiteboard will clearly demonstrate that the same instructions can be interpreted in very different ways given that the instructions are not precise.

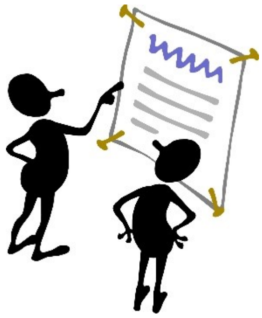
> The exercise demonstrates the need to give precise instructions and the difficulties over communicating to reach a common understanding.

PROGRAMMING EACH OTHER

Creating a robot buddy



Robots might seem smart, but they are dependent on help to understand the world and the tasks they are supposed to perform. But how do you talk to a robot?
The robot needs instructions that are precise, complete and correctly ordered. That is clear step-by-step instructions. Choose from every-day activities and make it obvious for the children that we always perform step-by-step activities, in order to cope with our lives. You have to put on your socks before you put on your shoes. Let the children reflect on some every-day activities. How do you go about; sitting on a chair, spreading marmalade on bread, tying your shoes, washing your hands.



> Let the children plan and design the instruction for the chosen tasks.

Example: Sit on a chair in front of a table

1. Pull out the chair from the table
2. Stand between the chair and the table
3. Sit down on the chair
4. Pull the chair towards the table

Is this sequence of instructions adequate? Can the instructions be misinterpreted? How can we make the instruction more precise?

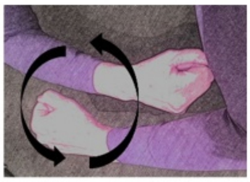
PROGRAMMING A DANCE

Present the different moves for the children. Try out all of the different moves a few times. Repeat the moves three times every exercise.

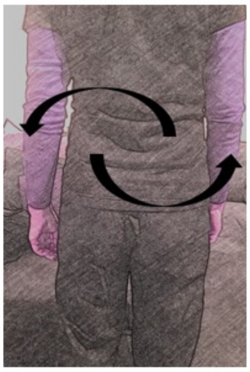
Clap your hands

Stamp your foot

Point upwards



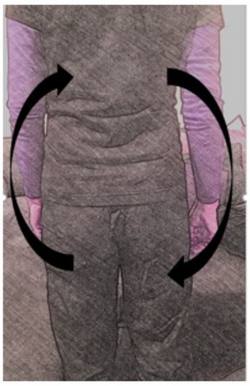
Roll your arms



Turn around

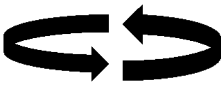
Kneel

Cross your arms



Shake your body

Combine the moves to design a dance. Use the whiteboard to make the sequence of moves visible for all. Engage the children to make the decisions.
Introduce the signs Loop and Curly brackets.



Loop: Discuss with the children the notion of repeated patterns.
Introduce the loop (the repetition) into the dance. Do not forget to assign a number of iterations (repeated movements) to the loop.

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Curly brackets: Discuss with the children how to repeat a sequence of moves that make up a unit.
Introduce curly brackets to the dance. What moves are to be performed together as a unit. Combine the units defined by the curly brackets with a loop. Define how many times the loop should be iterated.

Now the children are ready to program quite complex movements that define a dance.
The children will soon discover the need for a pulse or even a rhythm, so that they can coordinate the dance. Initially some drum-like object must be tapped to convey the rhythm. Let the children eventually choose some music to perform the dance. Probably the best way is to choose the music first and to design the dance according to the music.

EVALUATE & SHARE

Designing a complex dance and challenging the members of the class to perform the dance is very motivating. At some point the sequence will have to be noted. Let the children invent their own way of creating appropriate notes. This exercise is effective at demonstrating the need for communication, structure and standardization in order to coordinate common activities.
When one of the dances is well designed and the children appreciate it, it could be filmed. If the children feel proud of what they have achieved, they will most probably want to show the dance to parents and friends.

Inclined plane and progression of activities

R	S	T	E	M
ROBOTICS	**THE SCIENTIFIC METHOD**	**TECNOLOGY**	**ENGINEERING**	**MATHEMATICS**
Coding with bluebot	Problem solving, stepwise procedure	Physical and virtual Bluebot coding	Create and refine your design	Logical thought

DESIGN-EXPERIMENT-PROGRAMME

The experiment of “climbing the mountain” was performed in steps of progression. The first phase was exploratory with the purpose of being acuainted with the blue-bot and the problem of going up a steep hill (different wooden planks) In the second phase a more sophisticated “mountain” in the shape of a wood board was prepared and tilted in an angle to make it impossible for the robot to “climb the mountain” straight up. In the third phase a few items were attached to the wood board (mountain) e.g. a clear marking of a finish line and som obstacles. In the fourth phase a virtiual coding platform together with physical symbols (arrows) on small plasic squares were introduced.

1. GETTING ACQUAINTED WITH THE PROBLEM

The children had some prior experiences with the Blue-bot. They had been playing with them and knew the logic behind the arrows in programming the robot. The children were introduced to the problem: Can the Blue-bot climb a mountain? In order to answer the question the first thing to do was to build a mountain. The children were introduced to a variety of equipment. Plastic boxes, chairs, some wooden planks and some wood boards were available and the children started to experiment. The concept of “a slope” was explored and different designs constituting a mountain for the Blue-bot to climb were constructed.

2. DESIGNING THE MOUNTAIN

A wood board was choosen to be the most appropriate design of a mountain. The inclination was fixed by the teachers to be just as steep not allowing the Blue-bot to be able to climb the mountain straight up. A strategy of ziigzag was the obvious solution but would the children recognize that strategy? Just climbing the mountain caused some confusion so the teachers attached some plastic tape on top of the board indicating the goal. The words finish line was written behind the tape to make it obvious what the tape strip represented. The improvement with a clear goal made the children more focused and more satisfied in beeing able to more easily decide when the task was succesfully accomplished.The children struggled with the task of getting the Blue-bot to the top of the montain. They did not succed in solving the problem by programing the robot to reach the goal in one session. They had to program in segments and occationally literally “lend a hand” to the robot since it had a tendency to slide and slip on the surface.

3. IMPROVING THE DESIGN OF THE MOUNTAIN

In order to make the challenge more challenging the wood board was equipped with some obstacles. A fir cone, some wink balls and toy building blocks were attached. The obstacles made it more clear to the children that they had to program the Blue-bot in a zigzac way. But the problem with sliding and slipping did not disappear. There are some problems left to get a grip of.
This was part of the intention with the design of the mountain. We wanted to observe if the children would connect the behaviour of the robot with scientific concepts like friction, gravity, surface, force and so forth. The results of these observations will be presented in another forum.

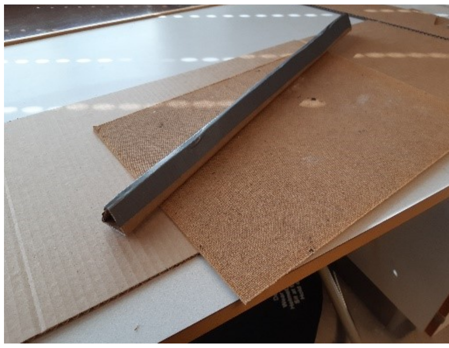
4. VIRTUAL AND FORMAL PROGRAMMING WITH SYMBOLS

The Bluebot app was introduced. In order for the children to explore and perform more formal programming. To further help the children to explore formal symbol-based programming the corresponding symbol represented on the physical blue-bot was presented in the form of plastic squares with the different symbols attached to them. The idea is for the children to represent the sequence of action the robot have to make in order to achieve the goal of climbing the mountain. This could be done by arranging the platic squares in a row, representing the sequence, or it could be done by programming the corresponing, virtual, symbols on the iPad by using the blue-bot app. The children were encouraged to describe the action of the robot by arranging the plastic squares. They did so, but the impression was that they did not appreciate the row of plastic squares representing a suggested sequence of actions as a help to think, or a help to solve the problem. The children tended to focus either on the physical Blue-bot or on what happened on the screen of the iPad. It is not clear how the children perceive and connect the formal signs with the actions of the robot. Do the formal programming aids like iPads or physical signs like arrows on plastic squares enhance digital competence with the children?. Does work with robotics foster exploration of scientific concepts? These questions remain to be adressed and explored further.

Inclined plane. Using a carboard box to build a mountain

R	S	T	E	M
ROBOTICS	**THE SCIENTIFIC METHOD**	**TECNOLOGY**	**ENGINEERING**	**MATHEMATICS**
Coding with Bluebots	Stepwise procedure	Construction work	Design by corrugated paper	Logical thought

DESIGN-EXPERIMENT



A cardboard box can be very useful to construct a mountain slope for the Blue-bot to climb up. In addition to the cardboard box, you will need a knife, preferably a wallpaper knife and duct tape. In our case, we also added some sandpaper and plastic film, so that the robot could climb up different surfaces.
You use the knife to cut the cardboard box that unfolds as a long rectangle of cardboard. Cut off the the top and the bottom flaps of the box. The cardboard flaps can be used to construct some ribbons or beams that can be attached beneath the slope, in order to stabilize the mountain. By cutting out cardboard strips 9 cm in width and folding them into a triangular shape, you can make beams that can be attached to the underside with duct tape, so that the slope will not sway.
You can also use pieces of cardboard and cut them to the shape of the slope, attaching them to the sides of the mountain with duct tape, in order to further stabilize the mountain. And, finally, you can use the duct tape to attach the mountain to the floor or table or wherever you wish to place it. The slope of the mountain will stand up firmly, presenting a challenge for the children to overcome.

If you wish to use the inclined plane to demonstrate the characteristics of different surfaces, you can add carriageways that consist of sandpaper, plastic film, cloth or whatever, and challenge the children to choose a road surface and to predict how the Bluebot will perform. Choosing is one thing, but explaining your choice will bring forward the need to use scientific concepts.