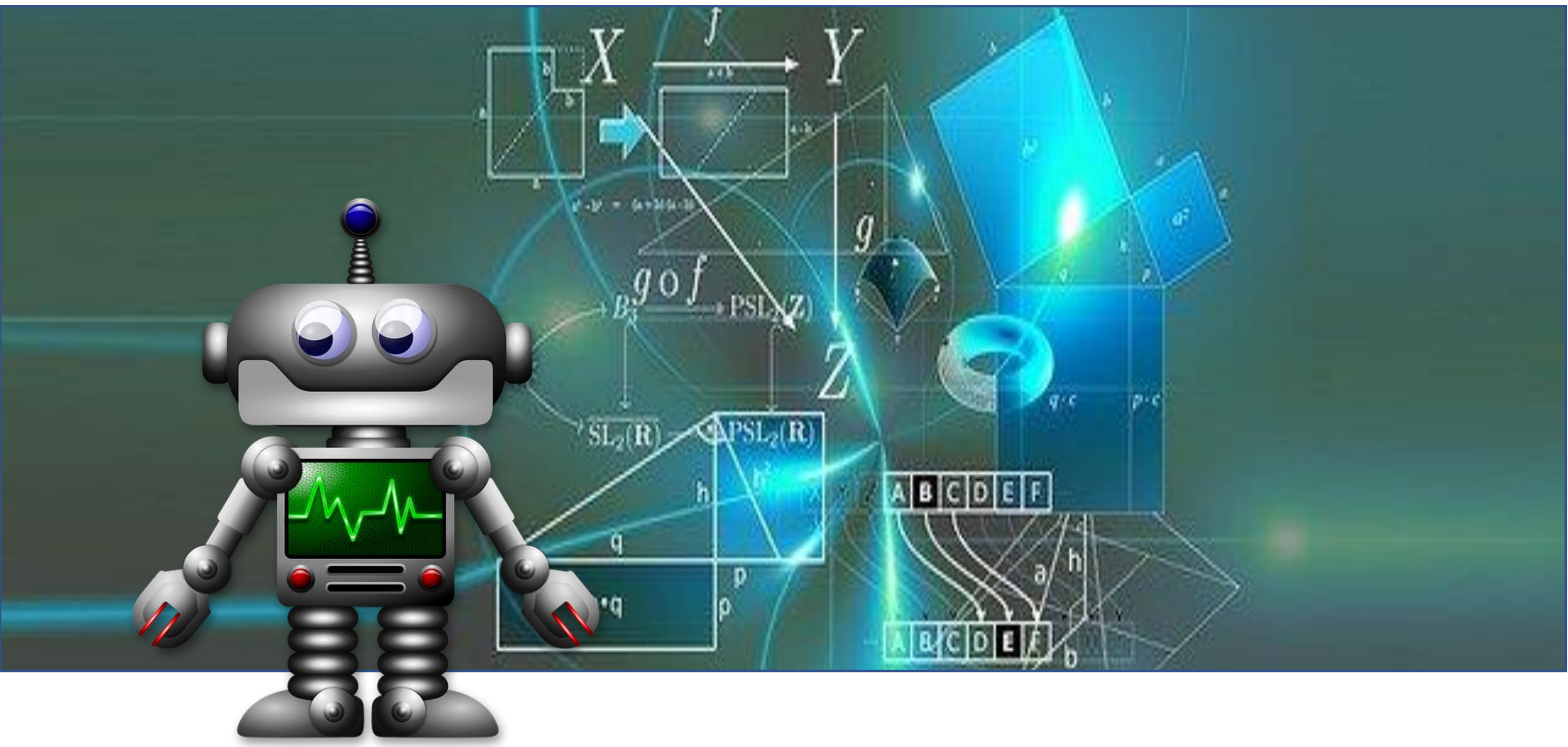
FLIPPED LEARNING PRACTICES TO RELEASE MATHS ANXIETY WITH THE USE OF ROBOTICS



HIGHER EDUCATION COURSE CURRICULUM
FOR PRIMARY SCHOOL PROSPECTIVE TEACHERS

RELEASING MATHS ANXIETY WITH THE USE OF ROBOTICS

With the support of the Erasmus+ Programme of the European Union

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Scuola di Robotica

UNIVERSITY OF LATVIA

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DOCUMENT INFORMATION

Project Information

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INTRODUCTION

Mathematics education is one of the keys to development in today's work life. It is one of the most effective instruments for reducing poverty, social exclusion and inequality since we use math in every aspect of our lives in practical everyday activities and at work such as solving problems, managing personal finance, keeping things well ordered and using quantitative skills required by a great number of jobs.

Primary school pre-service teachers play a crucial role to meet individuals' differentiating needs since the future will be shaped in their hands. Considering the individual differences in learning mathematics, most probably many would agree on the fact that some mathematics learners' excess amount of math anxiety that most likely causes a negative emotional state toward mathematics and low performance in mathematics. Although an acceptable degree of math anxiety is expected to motivate learners to study and focused on the task at hand, most of the time math anxiety is risk factor for some students for a comprehensive understanding of mathematics. As a result, our goal as educators should be to explore new tools to reduce math anxiety in teaching primary school mathematics. Among many alternatives, the flipped learning approach was chosen as a viable medium to reduce primary students' level of math anxiety with the use of robotics.

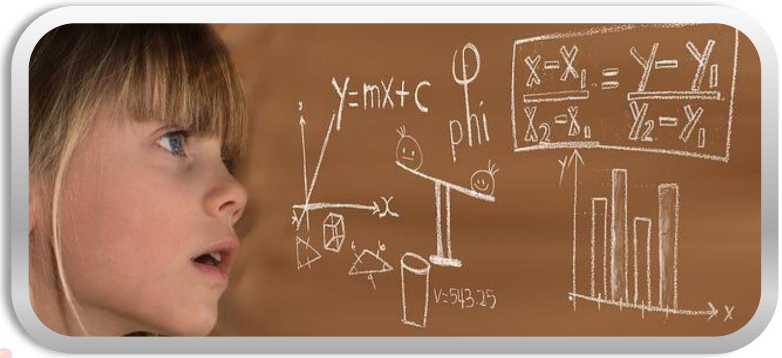
The main goal of this project is to enhance expertise of prospective teachers who are enrolled in primary teacher education programs. The project aims to help prospective teachers develop strategies in their work with students with high levels of math anxiety. Specifically, this two-year project plans to accomplish the following tasks:

- A modular curriculum designed with flipped learning including hands-on learning practices
- A video library including explanations for the use of robotics in maths education in primary schools
- Specifically, the project aims to reach the following objectives:
- To raise prospective teachers' awareness of mathematics anxiety
- To support prospective teachers who will face challenges while teaching children with MA
- To meet prospective teachers with innovative teaching activities that can be used to accelerate the learning processes of children with mathematics anxiety
- To obtain genuine, valid, and reliable data on the needs of prospective teachers related to the teaching activities to engage children with mathematics anxiety in the learning process more effectively

MODULE 1

MATHEMATICS ANXIETY

LESSON 1



Subject: The Concept of Anxiety

Duration: 1 hour

Learning Outcomes:

- To understand the main concepts, theories, research methods and results of anxiety
- To know the interaction between education and anxiety
- To formulate, analytically describe and present scientifically improved information about anxiety

Teaching Methods: Individual work, discussion, question-answer, collaborative learning.

Learning-Teaching Process:

<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic.

<u>In-class Activities</u>

- Prospective teachers are asked to think about word *Anxiety* and find out associations or other words which rise up when they hear word *Anxiety*. Individually Prospective teachers are making list of keywords as associations on paper in 1 minute.
- In a group of 4 or 5, prospective teachers share and discus lists of keywords.
- In the next step, prospective teachers should find common and different words and choose the most suitable according to the results of discussion in their groups.
- Prospective teachers generate a list of keywords with the main concepts from theoretical materials about anxiety. They look for the explanations of words in the list. Theoretical material includes definitions, symptoms, steps of anxiety etc. Prospective teachers prepare / visualize a theoretical material for presentation as picture.
- Groups present prepared pictures.

Assessment Techniques

Self-assessment about one's own pedagogical activity by the acquired knowledge, understanding and skills implementing systematically and consciously the math anxiety in the educational institution

Plan as one's own pedagogical work using the acquired knowledge, understanding and skills implementing systematically and consciously the math anxiety in the educational institution.

Theoretical Information

The Concept of Anxiety

Anxiety as being uneasy, hesitant, and afraid when the individual is confronted with the stimulus, although the individual does not know the reason (Kutluca, Alpay, and Kutluca,2015).

Anxiety emerges as a result of conflict and obstruction, and often reflects an unknown internal tension and uneasiness (Aydın, Delice, Dilmaç, and Ertekin, 2009).

Anxiety is "a vague fear without knowing what the real problem is" (Morgan, 2019).

Anxiety is an emotion that is characterized by a set of reactions to a certain thing or context (Mendes & Carmo, 2014). These reactions can be unpleasant physiological (eg. Tachycardia, sweating, cold extremities), escape and avoidance behaviors, and production of negative self-attribution and negative attribution (Carmo & Ferraz, 2012: Mendes & Carmo, 2014).

While anxiety appears with feelings of pessimism and hopelessness about the future, the anxious person feels physically and emotionally pressured and helpless (Alpay, 2004). Normal levels of anxiety are present in everyone and are necessary to deal with some situations. However, as the level of anxiety increases; it can prevent students from paying attention to what is learned. In this case, learning becomes difficult, individuals may lose their mental fluency, the student feels that he does not know anything and can lead to failure (Baylan, 2020; Davarcıoğlu, 2008, Gündüz-Çetin, 2020).

LESSON 2

Subject: The Essence of Maths Anxiety

Duration: 1 hour

Learning Outcomes:

- To know and aware the theoretical and practical aspects of math anxiety
- To know the interaction between math anxiety and mathematics education

- To think and reflect on one’s own internal world thus promoting empathy to learnersTo promote the development of their knowledge, skills, and competences in the field of education by focusing on math anxiety.

Teaching Methods: Individual work, discussion, question-answer, collaborative learning

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- The prospective teachers are first asked to identify anxiety in mathematics that they felt or observed in primary school. Prospective teachers individually reflect upon and report at least 3 factors, stimuli, or situations, which evoked anxiety in mathematics at school.
- After the prospective teachers discuss their responses in small groups. At the end the class discussed as a whole the anxiety that they had reported on in the questionnaires. The discussion moved from reporting their feelings of anxiety to analysing them professionally as teachers.
- After sharing and reflecting about experienced anxiety in mathematics, prospective teachers follow to the content of presentation *The Essence of Math Anxiety.*

Assessment Techniques

Self-assessment about one’s own pedagogical activity by the acquired knowledge, understanding and skills implementing systematically and consciously the math anxiety in the educational institution

Plan as one’s own pedagogical work using the acquired knowledge, understanding and skills implementing systematically and consciously the math anxiety in the educational institution.

Theoretical Information

The Essence of Math Anxiety

Mathematics anxiety is a condition that manifests itself in the form of solving mathematical problems in an individual's school life or daily life, and emotional tension or anxiety in performing number operations (Tobias, 1993). It is stated as an uncomfortable feeling that occurs when students need to do an assignment or task related to mathematics (Ma & Xu, 2004). Mathematics anxiety is versatile and intertwined with concepts such as fear, worry, and uneasiness (Baloğlu, 2001). Mathematics anxiety can be defined as “concern, fear, and aggressiveness which emerge together with physical symptoms observed while dealing with mathematics” (Sherman, 1976).

Mathematics anxiety occurs when fear is revealed physically and turns into bodily reactions in situations such as trembling, blushing, inability to breathe, heart palpitations, and fainting etc. (Davarcıoğlu, 2008). Mathematics anxiety as fear accompanying anxiety that creates an irritating feeling in the student when dealing with mathematics. Main characteristics of this discomfort state include dislike, worry, and fear, with specific behavioral manifestations such as tension, frustration, distress, helplessness, and mental disorganization. (Sarıgöl, 2019).

The factors that affect mathematics anxiety are age, gender, parental attitudes, education and professions, socio-economic status, number of siblings, and success of the child (Yenilmez & Özbey, 2006). A decrease in self-esteem and pleasure, hopelessness, fear, and feelings of shame also significantly affect mathematics anxiety (Aydın, 2011). Main reasons of the math anxiety can be listed as follows:

- Emotional and psychological characteristics of the learner, self-esteem perception, success expectations,
- Negative attitudes, prejudices, fears of learners towards mathematics,
- Parental attitudes, pressure,
- Mathematics has a nature that includes abstract concepts,
- Creating the perception by teachers that "doing mathematics requires a different skill and skill",
- Negative attitudes of teachers to demonstrate their expertise,
- Negative anxiety of teachers about mathematics and teaching mathematics,
- Wrong teaching methods, teaching activities used by teachers (Alkan, 2019; Baylan, 2020; Beilock, Gunderson, Ramirez, & Levine, 2010; Delioğlu, 2017; Deniz & Üldaş, 2008; Ergenç, 2011; Gündüz-Çetin, 2020; Hannula, 2006; Hlalele, 2012; Lazarus, 1974; Sade, 2020; Sarıgöl, 2019; Shields-Darla, 2006; Uusimaki & Nason, 2004; Yıldırım, 2016).

A math anxious student experiences math with more than a feeling of dislike or worry; it also affects physiological outcomes such as heart rate, neural activation, and cortisol (Faust, Ashcraft, 1996; Lyons & Beilock, 2012b). Higher-math-anxious students show increased heart rates (Faust, Ashcraft, 1996) and, when cued with an upcoming math task, show neural activations similar to those found when individuals experience physical pain (Lyons & Beilock, 2012b). The conditions for math anxiety can be environmental (bad experiences, bad teachers), personal (lack of confidence, low self-esteem), dyscalculia, or cognitive deficits. Emotional factors, such as general anxiety or self-esteem play an important role too (Orly-Rubinsten & Tannock, 2010; Dowker et al., 2016). Symptoms of math anxiety include:

- Emotional symptoms: feeling of helplessness; lack of confidence; fear of getting things wrong.
- Physical symptoms: heart racing; irregular breathing; sweatiness; shakiness; biting nails; feeling of hollowness in stomach; nausea.
- Frustration from trying to do math and not being successful.

- Not knowing where to start with questions or never getting the right answer.
- Confused and just wanting to quit and go home.
- Very stressed before and during exams.
- Begin to shut down and stop listening in class.

LESSON 3

Subject: Mathematics teaching/learning to release Math Anxiety

Duration: 1 hour

Learning Outcomes:

- To know and aware the theoretical and practical aspects of math anxiety
- To analyze, evaluate the situations to release anxiety in mathematics education
- To be able to make decisions corresponding to the concrete situation in the math education, including the ensuring of the teaching/learning process and the learning environment
- To analyze contextual factors that influence learners' involvement and academic achievement, applying consciously the strategies for releasing math anxiety

Teaching Methods: Individual work, discussion, question-answer, collaborative learning

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- The prospective teachers are first asked to reflect on topics: Mathematics teaching/learning without Anxiety and Mathematics teaching/learning with Anxiety. They are asked to think and find out differences in mathematics teaching/learning with/without anxiety, for instance, pupils with/without anxiety in math, teachers with/without anxiety in math and/or acquisition of math content with/without anxiety.
- In groups, prospective teachers draw a picture of two given cases in mathematics education: *Mathematics teaching/learning without Anxiety* and *Mathematics teaching/learning with Anxiety.*
- After presentation of group work, prospective teachers follow to the content of presentation *Mathematics teaching/learning to release Math Anxiety.* During the presentation, individually prospective teachers choose and put a note of important knowledge, findings for themselves.
- In the same group prospective teachers discuss notes and fulfil, make corrections, changes in prepared pictures. After groups present prepared pictures.

Assessment Techniques

Self-assessment about one's own pedagogical activity by the acquired knowledge, understanding and skills implementing systematically and consciously the math anxiety in the educational institution

Plan as one's own pedagogical work using the acquired knowledge, understanding and skills implementing systematically and consciously the math anxiety in the educational institution.

Theoretical Information

Mathematics Education to Release Math Anxiety

Mathematics anxiety, which is disturbing for students, causes the student to be afraid of the lesson and not to participate in the activities in the lesson. In addition, it is stated that it causes students to hate mathematics with increasing failure and decrease in learning rate (Alkan, 2010). Math anxiety is a negative emotional reaction that is characterized by feelings of stress and anxiety in situations involving mathematical problem solving. High math-anxious individuals tend to avoid situations involving mathematics and math-related careers than those with low math anxiety (Menon et al, 2012). Mathematics anxiety is a feeling of tension, an irrational emotional tray and anxiety in:

- solving mathematical problems
- using numbers, deal with numbers
- solve daily-life problems and academical problems (Şahin, 2000; Aydın, 2011; Richardson & Suinn, 1972).

Mathematical anxiety, which is an obstacle that affects students' education seriously, can also be defined as "unwillingness to deal with numbers or inability to equate in mathematical operations or fear against very simple four-operation problems encountered in daily life" (Alkan, 2011). Math anxiety as panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem (Sheila Tobias & Carol Weissbrod, 1980).

LESSON 4

Subject: Various Solutions to Release Math Anxiety

Duration: 1 hour

Learning Outcomes:

- To implement the theoretical and practical aspects of math anxiety for planning math teaching/learning
- To integrate the statements of anxiety in the understanding of mathematics education processes in the context of math anxiety releasing.

- To select the appropriate tactics and strategy of managing and planning the math education for releasing of math anxiety
- To reflect on one's learning process and results, and advance their further development of professional knowledge, skills and competence.
- To be able to make decisions corresponding to the concrete situation in the math education, including the ensuring of the teaching/learning process and the learning environment
- To use the acquired and consolidated knowledge in one's practical activities, integrating systematically and consciously the math anxiety in one's own pedagogical practice

Teaching Methods: Individual work, discussion, question-answer, collaborative learning

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- Group of prospective teachers choose one situation of various implementations to release maths anxiety in primary schools randomly:

    1. Supporting children with working with them privately and meeting their needs to feel capable.

    2. Start with the easiest topics and stagger the topics from easy to difficult to overcome the possible challenges.

    3. Motivate their students that they can be successful and promote group works to increase sense of belonging.

    4. Couple students with each other and promote peer support.

    5. Collaborate with parents to decrease the tension at home.

    6. Acknowledge students about their achievements with small rewards.

    7. Appreciate students when they become successful.

    8. Promote children for the active participation.

    9. Concretise abstract topics with modelling, visual examples and games.

- Prospective teachers should figure out solution and suggestions how to carry out and implement given condition in real math teaching/learning process. Prospective teachers use drama for showing results of group work.

Assessment Techniques

Self-assessment about one's own pedagogical activity by the acquired knowledge, understanding and skills implementing systematically and consciously the math anxiety in the educational institution

Plan as one's own pedagogical work using the acquired knowledge, understanding and skills implementing systematically and consciously the math anxiety in the educational institution.

Theoretical Information

Solutions to Release Math Anxiety

Two ways are suggested to eliminate students' mathematics anxiety: counseling techniques and techniques for developing mathematics skills (Baloğlu, 2001). Counseling techniques are effective on students with low anxiety level and little mathematical knowledge, but not much benefit for students with extreme anxiety or low mathematics knowledge was reported (Mathison, 1977; cited by. Keçeci, 2011).

Factor in the development of math anxiety is the fear of students making mistakes in the classroom in mathematics lesson (Zakaria & Nordin, 2008). Teachers should create a democratic and supportive classroom environment in order to enable students to alleviate their fear of making mistakes and to respond boldly. They should not ignore the contribution of a mistake both to understanding of the student who made the mistake and other students (Keçeci, 2011). The teacher's behavior and attitudes, and the atmosphere created in the classroom will play a critical role in the development of mathematics anxiety. The reason is that most of the students with mathematics anxiety stated that they had anxiety as a result of sharp, harsh, humiliating, and rude behaviors of teachers (Baydar & Bulut, 2002).

The negative attitude of the teacher causes the student to stay away from the teacher first, then from the lesson, and finally from the school (Baloğlu & Koçak, 2006). On the other hand, teachers' focusing all their attention and interest on a student or a group also reveals mathematics anxiety (Baydar & Bulut, 2002). It was stated that the students who were out of the attention and interest of the teacher could not understand the mathematics lesson and thought that they could not succeed. Lack of interest in the lesson brings failure with it. In order to prevent such situations, it is recommended that the teacher tries to give equal voice and responsibility to every student in and out of the lesson (Keçeci, 2011).

Time-limited examinations are the most significant reason of mathematics anxiety (Hembre, 1990; Jackson and Leffingwell, 1999). Therefore, teachers should try to apply alternative ways of measurement tools such as projects, research, homework, group works, development file, self-assessment and observation besides written or oral examinations.

Another factor causing mathematics anxiety is the negative attitudes and implementations of teachers during the math lessons (Baydar & Bulut, 2002). Teachers should be patient, tolerant and polite against their students in and out of the classroom and consider that they may be the reason for the development of mathematics anxiety in students. According to research results observed that teachers should carry out various implementations to release math anxiety in primary school:

1. Supporting children with working with them privately and meeting their needs to feel capable.
2. Start with the easiest topics and stagger the topics from easy to difficult to overcome the possible challenges.
3. Motivate their students that they can be successful and promote group works to increase sense of belonging.
4. Couple students with each other and promote peer support.
5. Collaborate with parents to decrease the tension at home (Demir & Durmaz, 2018)
6. Acknowledge students about their achievements with small rewards.
7. Appreciate students when they become successful.
8. Promote children for the active participation.
9. Concretize abstract topics with modelling, visual examples and games (Ertem-Akbaş, 2018).

MODULE 2

THE USE OF ROBOTICS IN MATHEMATICS EDUCATION IN PRIMARY SCHOOLS

LESSON 1

Subject: Mathematics and Computational Thinking

Duration: 1 hour

Learning Outcomes:

- To understand the concept of computational thinking,
- To engage in computational thinking,
- To apply computational thinking in mathematics
- To apply computational thinking in teaching mathematics

Teaching Methods: Individual work, discussion, question-answer, collaborative learning.

Learning-Teaching Process:

Before the Classroom Time, Prospective teachers will read the necessary background information regarding computational thinking prior to the lesson. They will also refer to online resources for in-depth understanding. They will watch online expert videos on computational thinking.

In-class Activities

- At the beginning of the lesson, the prospective teachers will be divided into groups of four.
- In their small groups, they will discuss basic characteristics and components of computational thinking. They will also take not of the similarities and difference between computational thinking and other forms of thinking.
- They will also discuss how computational thinking and mathematics are related during small group discussions. They will have their notes ready for the whole group discussion.
- The instructor will monitor group discussions, answer their questions and provide feedback.
- During the whole group discussion, the prospective teachers will share their notes with the rest of the class.

- Following the prospective teachers' sharing, the instructor will summarize basic aspects of computational thinking and how mathematics and computational thinking are overlap.
- Then, prospective teachers will go back to their small groups. In their groups, they will design an instructional activity to introduce primary school children to use computational thinking in mathematics.
- Each group will come up with the first draft of an instructional activity.
- The instructor will monitor their progress and provide feedback when necessary.
- Later, all activities will be shared with the whole group. Prospective teachers will share their thoughts on the activities.
- The instructional activities will be posted online.
- At the end, they will write a reflection paper on computational thinking and its relevance in teaching mathematics.

Assessment Tools: There are four different assessment strategies. These are as follows.

- Peer assessment is necessary to determine how the groups study
- Self-assessment is required to determine individual's assessment of own progress
- Writing an essay is essential for understanding the group processes
- Rubric evaluation is used for evaluating the designed activities

Theoretical Knowledge

Computational thinking is a necessary skill for all individuals regardless of what their professional focus is. Many would argue that only computer scientists need to use the tools of computational thinking. For others, computational thinking is a fundamental concept solely belongs to computer science. However, adults and children need computational thinking to read and conduct basic arithmetical operations for analytic thinking (Beecher, 2017). "Computational thinking is a kind of analytical thinking" (Wing, 2008, p. 3717). For an educated person, computational thinking is an asset to generate effective solutions to many problems. Computational thinking is the way of thinking algorithmically which is as important as conducting scientific experiments, performing art, and solving a challenging geometry problem. It supports the individual to think like a computer scientist (Grover & Pea, 2013). As a critical element of human cognitive structure, computational thinking has its unique elements with distinct characteristics (Riley & Hunt, 2014).

Computational thinking is an indispensable part of school mathematics. Mathematics school curricula should put a great emphasis on linking computational thinking and mathematics learning. Such a curricula will be able to strength the relationship between computational thinking and mathematics. Also, it is suggested that a strong emphasis on computational thinking will help reach a diverse body of students and teachers. Perhaps, more importantly, students will find the opportunity to think like a computer scientist as well as a mathematician (Weintrop, Beheshti, Horn, Orton, Jona, Trouille, & Wilensky, 2016).

Computational thinking originated with robotics and can be applied through mathematics. Many of the robotic problems of coding and computational thinking go hand in hand with mathematics. Robotics is seen as a tool. The teaching of science and mathematics benefits from analyzing the forms of mathematical reasoning used in science and from coordinating the teaching of mathematics and science in schools. This coordination is particularly useful in the education of primary school children.

Research in Mathematics Education has had a rapid and unexpected international success, with very few precedents in the world of science. Unexpected international success, with very few analogous precedents in the world of science. less than half a century, an autonomous scientific discipline with its own journals, conferences and publications, rigorous criteria to which all scholars and researchers in the world are subjected, leading to specific courses that have been held for decades in university faculties, specializations, masters and doctorates, research doctorates.

One of the most widely used methodologies in Italy for the development of teaching activities related to mathematics is P&PBL (Project & Problem-based Learning), in the belief that traditional science teaching/learning does not stimulate curiosity about natural events and everything related to phenomenology observed. Practical applications and the use of real contexts must be the "starting point" for the development of the scientific idea.

Mathematics and computational thinking are very similar in many aspects. In both skills as abstraction, generalization, decomposition, algorithmic thinking and debugging are needed (Atmatzidou & Demetriadis, 2016). Robotics by introducing computational thinking gives the possibility to improve students' skills to systematically process tasks and develop the sequenced step by step coding commands (Chalmers, 2018), furthermore littlest students can improve their fine motor skills while building robots such as Lego WeDo.

Robotics is a wonderful way to introduce students to computational thinking considering that students of different ages and genders can learn and gain the same level of computational thinking, however different teaching and learning methods may be needed (Daniela & Strods, 2019a). Of course, programming is a huge part of robotics as well as mathematics and it may look complicated, however nowadays there are a lot of graphic programming possibilities, for instance, Lego WeDo interface, that make it possible to make robots and program them even for the littlest students. Moreover, it gives the possibility to focus on developing students' computational thinking skills (Bers et.al, 2014) as well as improve their mathematical skills and/or show them how their skills can be used elsewhere.

LESSON 2

Subject: Basic Principles of the Use of Robotics in Mathematics Education in Primary Schools

Duration: 1 hour

Learning Outcomes:

- To define basic principles of using robotics
- To combine them in mathematics education
- To understand their meanings in primary school
- To use them in mathematics education for primary school
- To prepare a poster that has a puzzle of basic principles of using robotics in mathematics education in primary schools

Teaching Methods: Brain storming, mind mapping, discussion, question-answer, collaborative learning,

Learning-Teaching Process:

Before the Classroom Time, prospective teachers will use the online teaching materials to learn about the topic.

In-class Activities

- Prospective teachers are divided into heterogeneous groups of 4-5 people
- Each group discusses what basic principles of using robotics are
- After these discussions, each group are going to create their group’s mind map about basic principles
- After group discussions and creating mind maps, basic principles of using robotics are explained by the researcher/teacher
- Created mind maps and explained principles are compared by the prospective teachers
- After these comparing, finding the similar and different points of them
- Then, each group discusses how to combine them in mathematics education and determines group’s idea about this

- One member of each group presents group's idea about combining basic principles in mathematics education
- After that, researcher/teacher asks what the similar and different points of them are
- And later, determining these points, researcher/teacher asks what their meanings in primary schools are
- Each group decides their group's idea about it
- Later on, another member of each group shares the group idea
- Specifies the similar and different points of the groups' ideas
- At the end of these each group are going to prepare a poster which has a puzzle of basic principles of using robotics in mathematics education in primary schools

Assessment Tools: There are four different assessment strategies. These are as follows;

- Peer assessment is necessary to determine how the groups study
- Self-assessment is required to determine individual's assessment of own progress
- Writing an essay is essential for understanding the group processes
- Rubric evaluation is used for evaluating the mind maps and posters

Theoretical Knowledge

General Overview

The use of robotic applications in education provides students with significant gains. For this reason, rapid developments in robotic technologies have increased the number of such studies in the field of education. When the studies at the primary school level are examined, it is seen that there are studies on students' mathematical thinking and problem-solving skills (Hussasin, Lindh, & Shukur, 2006; Kapa, 1999), gender differences (Beisser, 2005) and their achievement levels in STEM fields (Barker & Ansorge, 2007; Mitnik, Nussbaum, & Soto, 2008; Nugent, Barker, & Grandgenett, 2008; Nugent, Barker, Grandgenett, & Adamchuk, 2009; Williams, Ma, Prejean, Lai, & Ford, 2007). It is seen that positive results have been obtained in these studies. Sullivan and Bers (2017) used a KIBO robot kit in their study.

The Basic Principles of Using Robotics in Mathematics Education

Use of robots in teaching mathematics has been a topic of discussion for several years (Felicia, & Sharif, 2014; Zhong & Xia, 2020). Robotics can be used for many different aspects in real life and in learning process. For instance, students can gain new knowledge through hands on activities which also helps to overcome obstacle that students are not able to focus on one activity for longer period of time (Daniela

& Strods, 2019b) since robotics include many different actions (planning, building, programming, testing etc.). This kind of activities also have a positive influence on students' cooperative skills (Smyrnova-Trybulska et.al, 2017).

It is stated that educational robotics has four main goals (Barak & Assal, 2018; Bers, Flannery, Kazakoff, & Sullivan, 2014; Chaudhary, Agrawal, Sureka, & Sureka, 2016; Ching, Yang, Wang, Baek, Swanson, & Chittoori, 2019; Karaahmetoğlu, 2019; Ucgul & Çagiltay, 2014; Yolcu & Demirer, 2017). These goals are;

1. To support the teaching of design, engineering applications, programming, artificial intelligence and robot production,
2. To support early acquisition and development of STEM knowledge and skills,
3. To develop broad learning skills (such as engineering design, product-oriented thinking, questioning, analytical thinking, etc.),
4. To increase individuals' willingness to engage in science, mathematics and technology and to

LESSON 3

Subject: Other Digital Applications (Serious Computer Games, VR, AR, etc.)

Duration: 1 hour

Learning Outcomes:

- To research and discuss digital applications that can be used in education.
- To understand what digital game is.
- To examine application examples of digital games in primary school mathematics education.
- To develop application suggestions for digital games in primary school mathematics education.
- To understand what Augmented Reality (AR) is.
- To examine application examples of AR in primary school mathematics education.
- To develop application suggestions for AR in primary school mathematics education.
- To understand what Virtual Reality (VR) is.
- To examine application examples of VR in primary school mathematics education.
- To develop application suggestions for AR in primary school mathematics education.

Teaching Methods: Collaborative learning, lecture, brain storming, discussion, question-answer, research.

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic. They all research about digital applications used in education before the lesson.

In-class Activities

- At the beginning of the lesson, prospective teachers and researcher/teacher discussed which digital applications can be used in education and which ones are suitable for primary school mathematics education.
- Prospective teachers are divided into heterogeneous groups.
- Each group chooses one digital application (Digital games, AR, VR, etc.).
- Fast and detailed research is done on the selected digital application.
- Each group discuss on definition of application, how it works, requirements, benefits and limitations of the selected digital application.
- Previous studies about digital application are researched by the members of the group.
- The learning outcomes of the primary school mathematics program are reviewed and the outcome that can be worked on with application is determined.
- A simple application draft is prepared.
- At the end of the lesson researches and application examples which design by groups are presented to the whole class.

Assessment Tools: Four different evaluation strategies can be applied. These are as follows;

- Peer evaluation is required to evaluate in-group work.
- Self-assessment is required to determine individual's assessment of own progress
- It is important to evaluate the effectiveness of the presentations of the groups.
- The most suitable application can be evaluated.

Theoretical Knowledge

In addition to teaching lessons with more than one teaching method, it is inevitable to use digital tools and materials as course material (Seferoğlu, 2006). Among information communication technologies, virtual reality, augmented reality, second life and flipped learning applications, robotics and coding and digital games have come to the fore as the most preferred technologies and applications by educators, especially in recent years (Yanpar-Yelken, 2019).

Since the information presented through the digital game world creates an engaging experience and a state of continuing interest, its integration into teaching processes and its use in the classroom environment has become important with the advancing technology in the last decade (Akgündüz, 2019).

Digital games used within the scope of teaching processes are defined by De Freitos (2006) as applications that use the features of video and computer games to create engaging and immersive learning experiences in order to achieve specified learning objectives, outputs and experiences.

The developments that emerged as creating an environment through the possibilities offered by technology or being articulated to the real environment have been the source of new applications that are used in many different places in your life. The developments arising with the input of technology range from the unreal to the virtual articulated to the reality and it is called Virtual Reality (VR), Mixed Reality (MR) to Augmented Reality (AR) (Çetinkaya, Demircioğlu, Özsoy, Duman, 2019).

Virtual Reality (VR)

It is a complete integration experience that transports users to a completely artificial three-dimensional world. In the virtual reality experience, users fully integrate with a simulated digital environment through various devices. In virtual reality, known as the most immersive technology, the user in a completely artificial digital environment is tricked into believing that after a VR headset or a screen is attached to the head, their brains can step into a new world where they can move, and interact with virtual objects on the screen (Kapucu, 2020).

The use of virtual reality in education is gradually increasing and application and game development studies continue for this purpose. While developing educational content in a virtual reality environment, attention is paid to the quality of the experience that will make students live. In addition to the virtual reality not providing the feeling of reality, attention should be paid to the fact that the content designed in the virtual reality environment is enjoyable for the student (Akman, 2019).

In educational environments where virtual reality is used, it offers advantages such as being able to conduct experiments that are not in real life, creating the feeling of being in physical environments that are difficult or impossible to go, turning boring lessons into a fun form, practicing an activity in daily life, and presenting the environment and events described in history lessons visually (Derman, 2012).

According to Brill (1994), benefits of using virtual reality in education are examining the places that actually exist but where students do not have the opportunity to examine and explore, creating and interacting with environments that are not normally possible to create, by presenting abstract concepts such as mathematical functions to students with different perspectives in interaction, the student can understand the subject better, creates a learning environment by learning by doing, graphs and equations that are difficult to understand visually become easier to understand.

Augmented Reality (AR)

The main purpose of using AR technology, which allows a user to see computer-generated data integrated into the world around him, is to increase the observed reality. AR, a technology that blends real and virtual information in a meaningful way, is an enhanced and augmented reality phenomenon by creating a bridge between virtual and real worlds (Bilgin, 2018).

When evaluated from a pedagogical point of view, AR enables students to develop skills such as interpretation, multi-directional thinking, problem solving, knowledge management, teamwork, flexibility, engagement and accepting different perspectives. AR technology is involved in studies in different fields of education such as natural sciences, computer and informatics, mathematics, engineering and humanities (Akgündüz, 2019).

According to Kapucu (2020), some of the educational benefits provided by learning environments supported by AR are supporting learning by enriching real objects with virtual items, supporting spatial learning, supporting understanding of system dynamics, making teaching materials more interesting and colorful, supporting touch learning (kinesthetic), interactive and individual learning is supported by the student and the material, increasing retention in learning.

In addition to the many advantages of using AR applications in the learning process, it brings some limitations and disadvantages. These psychological and mental limitations can be counted as prejudices of educators, technical knowledge and skill deficiencies, the time and difficulty of developing content, the content developed differs from device to device or in the environment used, students' individual differences and require cost (Akgündüz, 2019).

In virtual reality creating an artificial environment, the user cannot see the real world around, but augmented reality allows the user to see virtual objects attached to the real world. While augmented reality (AR) adds something new to the existing environment to enhance the real world, virtual reality creates a completely new artificial world. While AR may have a more commercial success today, VR is a new technology and is evolving rapidly. On the other hand, and technology, like AR technology, is becoming increasingly cheaper and widespread (Bilgin, 2018).

LESSON 4

Subject: Prospective teachers' Discussion on the Use of Robotics in Mathematics Education, Suggestions and Opinions

Duration: 1 hour

Learning Outcomes:

- To engage in discussions about using robotics in math education
- To make suggestions about using robotics in math education
- To create a poster containing the suggestions about using robotics in math education
- To summarize and reflect on all four lessons.

Teaching Methods: Collaborative learning, brain storming, discussion

Learning-Teaching Process:

<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic.

<u>In-class Activities</u>

- Following the first three lessons, the prospective teachers are divided into groups of four or five for discussions
- Each prospective teacher will share things that she/he gained during prior lessons
- They will discuss using robotics in math education in small groups
- They will generate suggestions and implications about using robotics in math education
- They will come up with four or five topics to be included in the list of suggestions or other implications
- Then, they will decide which topics should be in the group poster,
- After that, they will organize a schema to show their idea,
- They will share their suggestions about using robotics in math education with the whole group
- Later, they will prepare a poster about it.
- The poster must include ideas about how to use robotics in math education, relevant suggestions, and implications for teachers.
- A member of each group will share their main idea about it, then researchers will create a final poster using these main ideas,
- Finally, all prospective teachers will write an essay about the lessons to summarize.

Assessment Tools: Rubric evaluation is used for evaluating the posters.

MODULE 3

BLENDED LEARNING AND ITS PRACTICES IN PRIMARY SCHOOLS

LESSON 1

Subject: Need for blended education

Duration: 1 hour

Learning Outcomes:

- To discuss current educational approaches
- To explain the need for distance education
- To discuss the limitations of distance education and face-to-face education
- To understand the necessity of using distance and face-to-face education together

Teaching Methods: Discussion, lecture, question-answer, debate, problem solving, case study

Learning-Teaching Process:

<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic.

<u>In-class Activities</u>

- Prospective teachers are asked about their current understanding of education and their answers are analyzed altogether.
- Sample cases about the need for distance education are requested from prospective teachers. Case studies are discussed together.
- Sample cases related to the need for face-to-face training are requested from prospective teachers. Case studies are discussed together.
- The necessity of using distance education and face-to-face education together with prospective teachers is put forward on the grounds of the necessity.

Assessment Tools:

There might be applied three kinds of assessment tools for this lesson depends on teachers' approaches: formative assessment (reviewing of homework and papers), summative assessment (giving tests oral or written) to measure Prospective teachers' abilities and master skills) and diagnostic assessment (pre-test and posttest). Both written and test or oral assessment tools will be aimed at comprehension and measuring their higher competencies.

Theorical Knowledge

Rapid developments in information and communication technologies have led to significant changes in education systems, as in all areas of our lives. These changes are educational purposes and affect student / teacher roles, learning environments, tools and equipment, etc. The effects of technology on education; has brought along the research of new learning methods and environments in which technology is integrated in education. As a result of these researches; It is seen that learning tools, which include distance education activities carried out in the online environment and allow access to information, come to the fore. It is possible to list the advantages of distance education as follows (Altun, 2020; Bozkurt, 2017):

- Being systematic and planned
- Student-centered
- Providing equal opportunity to disadvantaged groups
- Providing time and space flexibility
- Being cost and efficiency based
- Providing the opportunity to benefit from the advantages of technology in education
- Contributing to lifelong learning
- Providing alternative education environments for older individuals
- Providing the opportunity to learners related to international education
- Giving the opportunity to learners with a learning environment at their own pace and level
- Providing an independent working environment for learners
- Students with the competence to be responsible for their own learning

Although distance education is seen as a very advantageous education model, many studies reveal that it has limitations when used alone. The limitations of distance education can be listed as follows: (Altun, 2020; Masie, 2000; Singh, 2003; Zembylas, Theodorou & Pavlakis, 2008):

- Failure to provide meaningful learning,
- He is insufficient in student-teacher interaction,
- Inability to motivate the learner,
- cause attention deficit in the learner
- Not suitable for individuals with lack of self-regulation
- Requires high technology literacy

- High cost
- Existence of learning material and instructional design deficiencies
- Absence of feedback or low feedback

This situation has directed education researches to learning environments where face-to-face education and distance education environments are integrated. It has been emphasized by many studies that blended learning environments should be created in which the strengths of face-to-face and distance education environments are integrated. (Graham, 2006).

LESSON 2

Subject: What is Blended Learning?

Duration: 1 hour

Learning Outcomes:

- To discuss how to combine distance education and face-to-face education.
- To understand and defines what blended learning is
- To explain common aspects of blended learning definitions
- To prepare a concept map, mind map for blended learning

Teaching Methods: Discussion, lecture, question-answer, collaborative learning, buzz groups, concept map, mind map

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- Prospective teachers are divided into heterogeneous groups of 4-5 people.
- Each group discusses how to integrate distance education and face-to-face education in the form of buzz groups.
- After group discussions, the concept of "blended learning" is introduced by the teacher.
- Different definitions of blended learning are expressed and common aspects of these definitions are determined.
- The learners in the group create their mind maps regarding the concept of “blended learning” and share them with each other.
- Each group prepares and presents the concept map of the concept of "blended learning".

Assessment Tools:

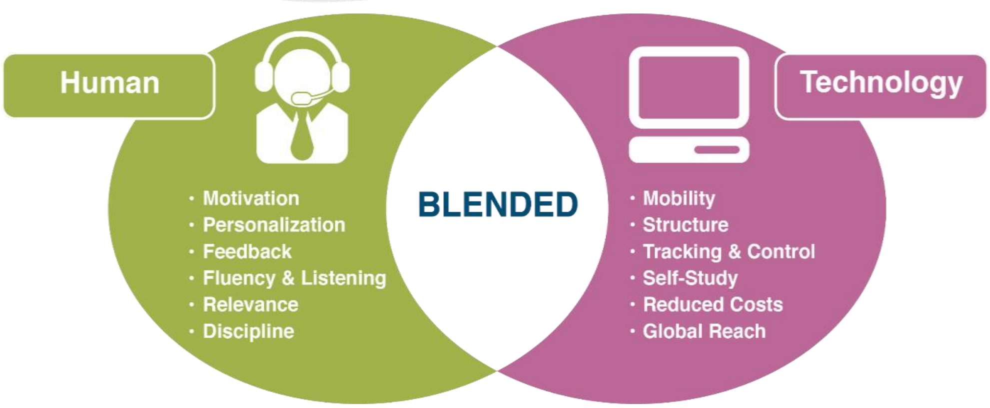
There might be applied three kinds of assessment tools for this lesson depends on teachers' approaches: formative assessment (reviewing of homework and papers), summative assessment (giving tests oral or written) to measure Prospective teachers' abilities and master skills) and diagnostic assessment (pre-test and posttest). Both written and test or oral assessment tools will be aimed at comprehension and measuring their higher competencies.

Theoretical Knowledge

Definitions of Blended Learning

- Blended learning is the combination of the advantages and strengths of both environments by combining web-based learning and classroom learning (Horton, 2000).
- Blended learning is the combination of web-based learning with the strengths and advantages of classroom learning (Osguthorpe & Graham, 2003).

When the literature on the definition of blended learning is examined, different definitions for blended learning stand out. In some of these definitions, while it is mentioned that blended learning is more effective in achieving learning goals and objectives, it is mentioned in some parts of bringing face-to-face and distance education together. In addition, in some definitions, it is mentioned that traditional education is blended with various possibilities of technology, and in others, different teaching methods are found together (Dürnel, 2018).



Considering the definitions of blended learning, it is seen that this learning approach is generally expressed as the use of different knowledge transfer methods in a learning method (Sloman, 2003). Lack of communication and interaction experienced in environments designed as e-learning causes students to develop negative thoughts towards these environments. For this reason, blended learning, which is the result of combining the positive aspects of face-to-face and online learning, has become an area of interest day by day (Fook, et al., 2005).

For blended learning environments to be implemented efficiently, students, teachers, administrators, and parents must fulfill their responsibilities. While the teacher and student are active in the content section, the administrator and parents should be involved in the support section. It is necessary to do the blending in a balanced way to see the advantages of strengths such as increasing the interaction between students and teachers, quality teaching and time. The aim should not only be keeping up with technological developments but should act in line with the need (Dürnel, 2018).

LESSON 3

Subject: Advantages of Blended Learning

Duration: 1 hour

Learning Outcomes:

- To demonstrate, illustrate, discuss the advantages of blended learning

Teaching Methods: Discussion, lecture, question-answer, collaborative learning, case study

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- Prospective teachers are asked to write their experiences regarding the blended learning environment in their education life as a group.
- Texts prepared by groups are presented by group speakers.
- The appropriateness of the learning experience experienced after each presentation to the blended learning approach is discussed by the class.
- Prospective teachers are asked whether they would prefer blended learning environments to their future professional life and are given the right to speak.
- Both shared learning experiences and the reasons for choosing blended learning environments in future professional lives are discussed in terms of "advantages of blended learning".
- A person selected from the class is given the task of writing and asked to write on a cardboard the "advantages of blended learning" expressed during the discussion.

- At the end of the lesson, what is written on the cardboard is handled by the class and necessary corrections and additions are made.

Assessment Tools:

There might be applied three kinds of assessment tools for this lesson depends on teachers' approaches: formative assessment (reviewing of homework and papers), summative assessment (giving tests oral or written) to measure Prospective teachers' abilities and master skills) and diagnostic assessment (pre-test and posttest). Both written and test or oral assessment tools will be aimed at comprehension and measuring their higher competencies.

Theoretical Knowledge

The Advantages of Mixed Learning

There are many studies that reveal the advantages of blended learning, which can be expressed as the integration of face-to-face education and distance education. When the information in these studies is organized, the advantages of blended learning can be listed as follows. (Batdı, 2014; Bath & Bourke, 2010; Çırak Kurt, 2017; Osguthorpe & Graham, 2003; Rovai & Jordan, 2004; Saliba, Rankine & Cortez, 2013; Smyth, Houghtan, Cooney & Casey, 2012):

- to increase learning opportunities,
- supporting course management activities such as communication, grading and providing feedback
- facilitating students' access to information and resources
- motivating students through collaboration and interaction
- providing effective and efficient learning experiences
- to develop a positive attitude towards the lesson
- to increase retention in learning and student satisfaction
- enabling students to control their own pace, learning process and learning activity
- to help students gain the habit of self-learning
- providing an environment for different learning styles

Wilson & Smilanich (2005: 14-16) categorized the benefits of blended learning as follows:

a. ***Reaching Education in a Wider Area:*** Using a single method in educational activities may cause difficulties in reaching the purpose of education in some cases. A training program to be used in the classroom can sometimes affect the number of participants based on a particular time and location. Thanks to this method, alternatives can be offered to students, and those who cannot be in the classroom environment can participate while the lesson is being taught.

b. ***Ease of Application:*** Blended learning applications are used by many institutions as they are easy to apply and respond to different learning needs.

c. ***Cost Effectiveness:*** Blended learning provides the opportunity to choose the most economical training solution for the needs of institutions.

d. ***Meeting Different Needs:*** Learning takes place in different ways from person to person. The predominant intelligence type of each individual may differ from each other. Accepting everyone equally in a classroom setting and assuming that everyone can reach the gains of the course with a single method cannot go beyond being too optimistic. Each student's learning style may differ from each other. Due to the many features of blended learning, it can offer different options to suit the needs of each student.

e. ***Advanced Education:*** The blended learning method provides an advanced education by producing both flexible and effective learning solutions for all organizations and individuals.

Advantages of blended learning; When we consider in terms of students, teachers and Institutions, we can categorize it as follows (Graham, 2006; Osguthorpe & Graham, 2003; Wilson & Smilanich, 2005):

a. ***Advantages and opportunities provided for students:***

- Active learning environment
- Providing an environment for different learning styles
- Acquiring necessary skills for using technology
- Students can flexibly access course-related resources from wherever and whenever they want.

b. ***Advantages and opportunities for teachers:***

- Providing convenience in reaching teaching gains
- Helping the lecture to be processed in the required time.
- Addressing different learning styles
- Using resources on the Internet with classroom activities
- Convenience to spend more time with students, one-on-one or in small groups
- Better communication with students
- Increased flexibility in defining and planning lessons

c. ***Advantages and opportunities provided for institutions:***

- Opportunities to interact with the institution and students
- Creating equal conditions for all students
- To have more opportunities to create environments that will provide educational experiences that are important for the purpose and content of the course
- Opportunities to respond to the different needs and competencies of students
- Increased efficiency in using electronic tools and resources

- Combining students of various levels in the same learning environment.
- Increasing the quality of communication between student-teacher and student-student
- Quick feedbacks
- Increase in school attendance and class pass rates

LESSON 4

Subject: How can Blended Learning Be Used in Mathematics Education in Primary Schools

Duration: 1 hour

Learning Outcomes:

- To be aware of the obstacles to success in primary school mathematics education and develop solutions.
- To reveal the need for blended learning in primary school mathematics education
- To examine application examples regarding the application of blended learning in primary school mathematics education
- To develop application suggestions for the application of blended learning in primary school mathematics education

Teaching Methods: Discussion, Blended learning, lecture, question-answer, forum, brainstorming, opinion scanning, collaborative learning

Learning-Teaching Process:

<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic. Also:

- During the distance education process: A forum is opened on the web 5 days before face-to-face training. The topic of the forum: "What are the obstacles to mathematics success in primary schools?"
- The opening of the forum is done synchronously by the instructor visually.
- The forum is left open to comments for 2 days asynchronously.
- Comments made simultaneously at a specified date and time at the end of 2 days are handled and discussed in a short online meeting.

<u>In-class Activities</u>

- Pre-service teachers are asked for solution suggestions for the problems dealt with in online education and answers are received quickly in the form of an opinion scan.
- It is discussed whether it will be efficient to use blended learning environments in these solutions.

- Prospective teachers are divided into heterogeneous groups of 4-5 people.
- One of the attached links is shared with each group.
- Each group examines the content of the link provided to them as a group and makes short notes.
- After the group work is over, a spokesperson from each group presents the practices related to their contents to the class. Respond to questions not understood by the class
- Each group is asked to develop a proposal for the application of blended learning in mathematics education in primary schools.
- These suggestions are shared in the relevant online forum.

Assessment Tools:

There might be applied three kinds of assessment tools for this lesson depends on teachers' approaches: formative assessment (reviewing of homework and papers), summative assessment (giving tests oral or written) to measure Prospective teachers' abilities and master skills) and diagnostic assessment (pre-test and posttest). Both written and test or oral assessment tools will be aimed at comprehension and measuring their higher competencies.

Theoretical Knowledge

New learning methods have started to come into tool in order to break students' prejudices against mathematics, increase their desire to learn mathematics and make them more understandable. As a matter of fact, one of the areas where technology integration is most needed in teaching is mathematics education, which is perceived as abstract for students. In the NCTM Position Report on the role of technology in teaching and learning mathematics, it was stated that in order to improve students' understanding, keep their interests alive and increase their competence in mathematics, it was stated that the opportunities in technology should be used in the best way and students should have access to mathematics thanks to the strategically used technology (https://www.nctm.org / Standards-and-Positions / NCTM-Position-Statements /)

According to the PISA (Program for International Student Achievement) 2012 report, the level of students' ability to use mathematics is associated with the richness and competence of the education they receive. Providing students with a rich educational environment and designing learning environments in which they take an active role will increase their participation in the lesson and thus, their motivation will increase, and efficient learning environments will be provided (Dürnel, 2018).

Mathematics is not just about four operations across the board in the classroom. Providing students with metacognitive knowledge, skills and attitudes related to mathematics knowledge that they may need in their daily life and education and training periods It is of great importance that students manage their self-learning processes, develop a positive attitude towards mathematics, approach mathematical problems and operations in a self-confident way and increase their self-efficacy perceptions positively.

- In order for students to be successful in mathematics (Dursun, 2018; Dürnel, 2018):
- enabling them to learn through mathematical experiences,
- allowing abstraction and association,
- using computers via the internet to access information and evaluate, store, produce, present and secure information exchange,
- the necessity of effective communication by participating in common networks has been revealed by many studies.

With the help of information and communication technologies that make it possible to see different forms of representation of concepts and the relationships between them and enable students to discover mathematical relationships, environments should be prepared for the development of students' skills such as problem solving by modeling, communicating and reasoning. At this stage, using blended learning environments will bring success in mathematics education.

MODULE 4

FLIPPED LEARNING AND ITS PRACTICES IN HIGHER EDUCATION

LESSON 1

Subject: What is Flipped Learning?

Duration: 1 lesson hour

Learning Outcomes:

- To understand and define flipped learning,
- To discuss the digital learning tools that can be used prior to the face-to-face sessions.
- To explain differentiating aspects of the flipped learning from the blended learning,

Teaching Methods: Discussion, lecture, question-answer, debate, problem solving,

Learning-Teaching Process:

<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic.

<u>In-class Activities</u>

- Prospective teachers will read the necessary background information regarding flipped learning before the in-class session. They will watch the expert video explaining flipped learning.
- They will present the class what they learnt about flipped classroom,
- They will break into four-five groups to discuss digital learning tools (videos, presentations, online dictionaries, etc.) that can be used prior to the face-to-face session
- In each group, prospective teachers will compare flipped learning and blended learning.

Assessment Tools:

Peer assessment, self-assessment, rubric evaluation and an assignment (e.g. preparing an essay, a ppt presentation, a mind map, a flipped lesson sample, etc.)

Theoretical Knowledge

Flipped learning is an instructional approach which can be defined as moving the traditional lecture from classroom to online and moving what students do at home to the classroom. It combines various methodologies for improving student teaching (Bergman & Sams, 2012).

In flipped classrooms, delivery of the essential subject matter is being done online with videos, readings or podcasts so what teachers usually do in face-to-face classrooms are transferred to online platforms. When they get to the school the time is spent on clarifying students' questions about the subject matter, solving problems, doing experiments, conducting discussions, engaging in group work, and sharing what they have learned with the class. As a result, we assume more and substantive student engagement and learning during the face-to-face time.

Flipped learning extends the in-classroom learning beyond the borders of classroom time through the use of online platforms. In flipped learning, students receive direct instruction through videos and other media; and the class time is devoted to engaging students in collaborative, interactive and hands-on activities (Flipped Learning Network, 2014).

In Flipped Learning, direct instruction is delivered outside of the classroom and generally before face-to-face education by using videos, presentations, or other online means of delivery. Class time, then allows students to engage in peer collaboration, hands-on activities, deeper debates, and personalized educator guidance. Flipped Learning replaces teacher-centered classroom with student-centered learning environment by giving more autonomy to the students in their learning and gives the educator a role of facilitator (Francl, 2014).

LESSON 2

Subject: Benefits of Flipped Learning

Duration: 1 lesson hour

Learning Outcomes:

- To understand and define benefits of flipped learning,
- To share what benefits they gained from the flipped learning experience in the previous lesson. To discuss the challenges faced during the flipped classroom practice,
- To prepare a word search puzzle in groups including the keywords associated with flipped learning (e.g. https://thewordsearch.com/maker/),

Teaching Methods: Discussion, lecture, question-answer, collaborative learning,

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- Lecturer opens a question-answer session to see what benefits of flipped learning are adopted by the prospective teachers.
- Prospective teachers talk about the previous lesson where flipped classroom was implemented.
- Prospective teachers share their opinions and discuss which benefits they gained.
- They get in groups and discuss other possible benefits of flipped classroom together with its challenges.
- They take notes and make a list of pros and cons of flipped classroom
- Then they work together in their groups and produce a simple online word search puzzle including the keywords associated with flipped classroom.

Assessment Tools:

Peer assessment, self-assessment, rubric evaluation, and an assignment (e.g. preparing an essay, a ppt presentation, a mind map, a flipped lesson sample, etc.)

Theoretical Knowledge

Benefits of Flipped Classroom

Activated Learner

Students take charge of their learning in flipped classroom (Bergman & Sams, 2012). They gain insight into self-directed learning. They read books, articles, notes, and other informative materials, watch presentations or videos to obtain this information before the lesson. Flipped learning is about bringing the learning process outside the classroom (Waterworth, 2014). This happens before face-to-face teaching process, which is why this learning model is also called as “Inverted Learning”.

Saving Time

Flipped learning saves the time of the educators which they will spend on giving the lecture in the classroom (Halili, Abdul Razak, & Zainuddin, 2014).

Changing Role of Teacher

Teachers have the possibility to move from the instructor role to the role of a coach, helper, consultant etc. and it creates a more productive and professional relationships between students and teacher (Talbert, 2017), students and teacher are equal during onsite activities.

More Time for In-Class Activities

Flipped learning gives the possibility to engage students' higher order thinking as well as deep thinking (Waterworth, 2014) during the class activities such as discussions, debates, problem solving, mind maps etc.

Flexibility in Making Progress based on the Learning Pace

When the students listen to a lecture in the classroom, they will have limited time to process the information provided. However, in flipped learning, students will be able to review the content before the lesson many times and allocate more time for comprehension in line with their learning pace (Giannakos, Krogstie, & Sampson, 2018).

LESSON 3

Subject: How can Flipped Learning Be Used in Higher Education Practices?

Duration: 1 lesson hour

Learning Outcomes:

- To demonstrate, illustrate, discuss how Flipped Learning can be used in higher education courses.

Teaching Methods: Discussion, lecture, question-answer, collaborative learning,

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- Prospective teachers get into groups of four or five.
- They are asked to choose a topic to teach and prepare a poster demonstrating how flipped learning can be used in this lesson (including information about the content of the digital materials, in-class activities, and follow-up of the lesson).
- Each group speaker demonstrates the poster prepared and explains the steps.
- The whole class discussions are maintained to evaluate the appropriateness of the methodologies proposed.
- The discussions will continue about how the prospective teachers would like to use flipped learning in their course delivery in their future professional life.

Assessment Tools:

Peer assessment, self-assessment, rubric evaluation, and an assignment (e.g. preparing an essay, a ppt presentation, a mind map, a flipped lesson sample, etc.)

Theoretical Knowledge

Flipped Learning Models That Can Be Used in Higher Education

1. **Traditional flipping**

This is the standard application of flipped learning that students get prepared for the lesson by watching videos or presentations and reading suggested information on the computer (online or not) at home.

Then, when they come to the classroom, they practice key concepts by doing exercises, carrying out discussions, working in groups to expand their comprehension.

2. **Debate-oriented flipping**

The before-class preparation includes watching videos which will set the ground for face-to-face debates in the classroom. Therefore, the chosen videos or presentations should contain information through which students discuss different aspects of the handled topic and improve their argumentation skills.

3. **Demonstration-based flipping**

This application successfully works for the subject areas requiring laboratory experiments. The educators record a video of themselves demonstrating step-by-step activities for example, the steps of a chemical reaction.

Students study the steps at home/before the class and then replicate the procedure in the classroom. The in-class activities continue with validation of results, revision of the steps together and further explanations.

4. **Group-based flipping**

This application is based on increasing student interaction through group work and learning from each other. Students digest video content before the class and then work in groups and exchange information to understand the content together.

5. **Virtual flipping**

This application is very useful for the circumstances when teacher and the students can’t come together face-to-face. All learning process is maintained through virtual interactions, first individual work to digest the content and then online meetings to discuss it.

6. **Double-flipped classroom**

In this application, students act as the instructor by recording their videos to show mastery and new skills. In this way, they gain more insight into the information they worked on, developed, and recorded (Seganmüller, 2020)

LESSON 4

Subject: Students' Practices on Flipped Learning Practices

Duration: 1 lesson hour

Learning Outcomes:

- To research sample flipped classroom practices used in higher education courses
- To make a presentation about best practices of flipped learning in higher education.
- To prepare a flipped classroom content (video, presentation, text, audio, games) for an implementation of flipped learning,
- To discuss how flipped learning practices can be improved for better results,

Teaching Methods: Discussion, flipped learning, lecture, question-answer, brainstorming, collaborative learning

Learning-Teaching Process:

<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic.

<u>In-class Activities</u>

- Prospective Teachers get in groups of four or five before the class time and make research on the flipped learning examples.
- Groups choose their topics to teach and work on the joint documents online; develop content
- Each group sends its content to another group to initiate learning process.
- Each group studies flipped learning materials they received and then they meet in the classroom. Each group will only study one material.
- Each group presents their in-class activities to other groups and explain how they structured the flipped learning process.
- Group members share their evaluations of the developed flipped learning materials of other groups.

Assessment Tools:

Peer assessment, self-assessment, rubric evaluation, and an assignment (e.g. preparing an essay, a PPT presentation, a mind map, a flipped lesson sample, etc.)

Theoretical Knowledge

How to Design Flipped Learning?

1- **Video + Structured Activity**

Instructor prepares a video content or finds a good video (on YouTube, TED Talks, FLN, Khan Academy or Coursera) about the intended content.

Structures the class time with the activities that will continue face-to-face.

2- **Text + Structured Activity**

Instructor writes an essay on the handled topic or finds a good article or a step-by-step instruction for a process depending on the subject to be learnt.

Instructor can annotate an existing text by using Perusall or Hypothes.is (social annotation software) to attract the attention to some very important points.

Structures the class time with the activities that will continue face-to-face.

3- **Audio + Structured Activity**

Instructor prepares an audio recording including his/her explanations or finds a voice recorded lecture, a music, a dialogue (e.g. for foreign language lesson), a poem, or a podcast directly related to the lesson topic.

Structures the class time with the activities that will continue face-to-face.

4- **Games + Structured Activity**

Instructor prepares an online game or finds a game suitable for the intended learning outcomes. (For example, book widgets)

Structures the class time with the activities that will continue face-to-face.

5- **Simulations + Structured Activity**

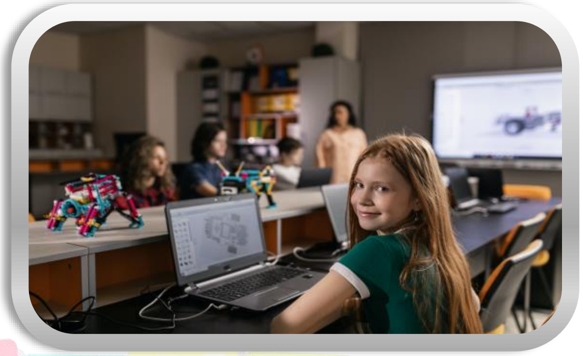
Instructor finds a simulation or simulation game and asks students to play it before the class time. It is good for hands-on activities, to gain deeper comprehension for process steps and know-how.

Structures the class time with the activities that will continue face-to-face (Talbert, 2017)

HOW TO USE ROBOTICS IN MATHEMATICS EDUCATION IN PRIMARY SCHOOLS

LESSON 1

Subject: Robots and Coding



Duration: 2 hours

Learning Outcomes:

- To develop skills to introduce robotics into the curriculum without a great prior technical knowledge.
- To explore the diversity of educational robots
- To understand the basic robotic anatomy and functions
- To understand the basic concepts of block-based visual programming language.
- To know how to select robots according to students, contents, and exploration contexts.

Teaching Methods: Flipped learning and blended approach. Demonstration. Group and collaborative work.

Learning-Teaching Process:

<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic.

<u>In-class Activities</u>

- Students will be divided into groups. A robot type will be assigned to each group... The robots should be chosen according to those most used in schools of each partner country. E.g. Bee-Bot, DOC, mBot, Lego WeDo.
- Each group will have to prepare, for the face-to-face class, a short presentation of the robot's functionalities. Types of Adductors, Effectors, Sensors, and coding platforms.
- In the classroom, students present their robots and discuss their pedagogical potential.
- Students will be invited to explore a programming task with directional robots, such as bee-bot or Doc.
- The scratch programming environment will be presented for students to carry out a task exploring basic programming principles: Creating objects, variables, loops, and conditions.
- In groups, students will develop a small project using scratch.
- Visual coding platforms for robots, such as mBlock, or Lego WeDo, will be presented.

- Students will be asked to develop a small project using one of these robots.

Assessment Tools:

Presentation and critical reflection of the projects developed with the robots.

Theoretical Knowledge:

Historically children have played with physical objects to learn a variety of skills. Tangible interfaces may be of significant benefit to education by enabling children to play with actual physical objects augmented with computing power.

Educational robotics gives children the opportunity to relate tangible concepts with abstract and computational thinking. Educational Robotics is driven in Papert's constructionism approach, engaging children in making their own meaningful constructions, "objects-to-think-with", to accomplish better achievements and significant learning. Robots and visual programming interfaces offer great scenarios for children explore math abstract concepts in a tangible and concrete way, mitigating math anxiety.

Various kinds of educational robotics are available for use in education. However, using robots as an educational tool depends on how they fit into the children's worlds, teachers' conceptions regarding learning and teaching and the educational setting as a whole.

As educational artefacts robots can be used in diverse approaches. Children can explore robots as receptors: observing, interpreting, and understanding its functionality and appropriating its meaning, or they can use robots as producers: interacting, acting, manipulating, and creating significant objects and projects.

Using technology, programming and robotics in education demands that teachers master, in addition to content knowledge and pedagogical knowledge, the technological knowledge. It is therefore essential to provide the student, future teacher, with digital skills that speed up the recognition and mobilization of the pedagogical potential of robots to deal with mathematical anxiety.

This session seeks to explore a more technical and instrumental dimension, in order to develop minimal programming and working skills with robots.

Hardware represents the robot body, its anatomy and physical forms with actuators, effectors, and sensors. Actuators are mechanism that introduce movement, such as motors. Effectors allows the robot to move, change shape and interact with the environment, for example a robotic arm. Sensors are means used to collect environmental data, for example reacting to touch or obstacles, recognize movement, read data such as temperature or luminosity.

Software allows the control of the robot's physical components, allowing to perceive the environment and to act on it. Depending on the type of robots, we use different programming languages and platforms. The directional ground robots, simpler and suitable for younger children, use programming techniques based on directional keys, very similar to the LOGO language. Other robots use visual programming platforms. The most popular visual programming platform is Scratch, and many of the robot's programming platforms follow a similar syntax. It is important that students, future teachers, understand and experience programming in these environments.

LESSON 2

Subject: Spatial skills related to geometry and arithmetic

(Spatial learning, 3D spatial skills, angle of rotation, directionality position on a plane, measurement, numeracy, problem solving (e.g., estimation, evaluating solutions, trial and error) and representation of many problems, Geometry, Addiction, subtraction, multiplying, Measures: length, perimeters)

Duration: 2 lesson hours

Learning Outcomes:
Preliminary Explanation: In children, especially between the ages of six and seven, the concept of right and left is still not well established. Possessing this concept means, on the level of mathematical knowledge, having access to geometry, and therefore we cannot begin to work on arithmetical and/or geometrical concepts if we do not work on the spatial orientation and skills of the children. Without these spatial skills children will have difficulty working on angles, figure construction, etc.

- To learn how to develop students' geometrical skills for STEAM competences
- To explore problem-based learning as a way to work with unplugged coding to deal with math anxiety
- To understand the importance of working with unplugged and plugged activities to promote computational thinking
- To develop a Math curricular subjects to design teaching learning activities that use robots
- To explore and recognize the use of robots to foster learning about location and orientation in space, geometric figures, distance and length and addition and multiplication
- To study the different didactic approaches to work with robots with children aged 6-8 and children aged 8-10 years

Teaching Methods: Discussion, flipped learning, lecture, question-answer, brainstorming, collaborative learning

Learning-Teaching Process:

<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic.

<u>In-class Activities</u>

- Prospective teachers examine the learning activity described below. They learn how to apply this activity during their internship.
- Creation of bracelets in different and distinct colours (pay attention to the colours chosen because if we choose similar colours children with visual impairments may have difficulties).

- The children will have to create the bracelets with paper and coloured cardboard, and in this way, it will be the final user who will create the instrument they will need for the exercise, creating engagement and curiosity through the methodology of "creation of the instrument", a key element of the exercise because it allows them to learn and put into practice fundamental skills such as fine motor skills.
- Once the construction of the two bracelets (right and left) has been completed, the children will have to wear them, making sure that all the students wear the same colour bracelet for the right and left.
- At this point we are going to put the orientation exercises into practice.
- We can do this in two different ways:

  Methodology of embodiment (proprioception): we will build a maze on the floor with adhesive tape or obstacles such as chairs and desks, and the child will move around the space following instructions.

  The aim is to get to the end of the path by following the instructions given by his/her classmates, which will allow the involvement of the whole class group. To give the instructions, the students will have to use the colours of the bracelets to indicate left and right.

  Methodology of heteroception: in this case, another child, placed in front of the child doing the exercise, will give the instructions from his own point of view (heteroception), so that the one giving the instructions will have to understand the right and left of the other.
- At this moment a third object intervenes, which can be the robot. We can use a real robot, and, in this case, we have several solutions such as Bee Bot, Blue Bor, Mtiny, as outlined above.
- We create the pathway in which the robot will have to move, so with paper, cardboard, markers and crayons we draw the pathway that the robot will have to follow and the children will have to design the pathway of the robot in order to be able to program it. In order to do this, the children will produce cards to indicate left and right and use the same colours as in the previous activity, thus creating a link. We are not yet thinking about measurements and angles but only about orientation, which is fundamental for acquiring later skills.
- Prospective teachers get into groups and each group designs a new similar learning activity to develop children's spatial perceptions and skills by using robots.
- Groups share their learning activities and discuss them with each other.

Challenges / Problems:

To create and use the bracelet

To use the bracelet to calculate space, measures, length

To program robots to move in different directions.

Geometry and Mathematics involved

Spatial orientation and length measures

In coding the robots: addition, subtraction, division.

Resources

Paper, carboard, coloured pencils, markers

Paper adhesive tape to build maze on the floor

Educational Robots (ie: Blue Bot, mTiny, etc.)

Plasticine and other art crafts materials (to represent streets, buildings).

Robotics kits

Assessment Tools:

- Self-assessment is required to determine individual's assessment of own progress
- Writing an essay is essential for understanding the group processes
- Rubric evaluation is used for evaluating the designed activities
- Peer assessment: A prospective teacher simulates lecturing a colleague as if he were a child.

Theoretical Knowledge

Sutton and Williams (2007) define spatial ability as "the performance on tasks that require: mental rotation of objects, the ability to describe and understand how objects appear at different angles, an understanding of how objects relate to each other in space" (Sutton et al., 2005). In their research, Authors outline that a substantive feature of spatial abilities is three-dimensional (3D) understanding, which is the capability to extract information about 3D properties from two-dimensional (2D) representations. This skill requires perceptual abilities to interpret what is seen, and spatial abilities to mentally manipulate graphical representations.

For math comprehension, the section on geometry, although often under-appreciated in k-12 school, is critical for understanding STEM; especially the disciplines of Technology and Engineering and the Arts. This module requires undergraduate students to take a broader view of the power of geometry by calling on students to analyse characteristics of geometric shapes and construct mathematical arguments about the geometric relationships, as well as to use visualization, spatial reasoning, and geometric modelling to solve problems.

Many Authors (Carme, Sutton, Highfield, Verner) recommend to introduce visualization and spatial abilities at the primary school level, insisting on the importance of acquiring these abilities of visualization learning in engineering education and specifically in developing 3D spatial skills and in contributing to student success. Highfield (2010) described a series of tasks using Bee-bots and Pro-bots, developed as part of a larger project examining three- and four-year-old children's use of robotic toys as tools in problem solving. The key idea was that children program the robotic toys and observe their various movements. Through the proposed activities, various mathematical concepts and processes were promoted: spatial concepts (e.g., capacity, angle of rotation, directionality position on a plane), measurement, numeracy, problem solving (e.g., estimation, evaluating solutions, trial and error) and representation of many problems.

Verner (2004) used a learning environment (RoboCell) where manipulations of the objects were performed by robot operations that required spatial thinking. The author proposed a curriculum related to robot kinematics and point-to-point motion, rotation of objects and robotic assembly of spatial puzzles. Pre- and post-course tests performed in middle and high schools demonstrated the improvement of the spatial abilities of students in tasks that were practised in the course.

LESSON 3

Subject: The Concept of Estimation

(Spatial learning, 3D spatial skills, angle of rotation, directionality position on a plane, measurement (also with a ruler), numeracy, problem solving (e.g., estimation, evaluating solutions, trial and error) and representation of many problems, Geometry, Addition, subtraction, multiplying, Measures: length, perimeters, Time estimation)

Duration: 2 lesson hours

Learning Outcomes:

- To learn how to teach estimating a distance
- To learn how to teach estimating a quantity
- To learn how to teach estimating time

Note: For the development of spatial skills and geometry, it is necessary to be able to estimate, so we are going to work on the concept of time and measurement linked together.

Teaching Methods: Discussion, flipped learning, lecture, question-answer, brainstorming, collaborative learning

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

Distance estimation

- Prospective teachers will examine the example learning activity below to learn how to teach distance estimation.

Example Learning Activity

- We can use one of the robots mentioned in the appendix section, which at each command makes a straight line 15 cm long. To carry out this exercise, we need to work out how many 'steps' the robot takes to get to a particular point and cover the distance we have chosen.

- For this activity we can work on *multiplication*: if the robot takes one step to cover 15 cm, then if it takes three steps it will cover 45 cm of distance and then work with the students to work out how many steps are needed to get to a point. These skills are needed to gain awareness and tools for learning mathematics and the rudiments of coding.
- The next step involves the use of *measuring with a ruler* as a tool for refutation and verification.
- To work on estimation, we need to place an object randomly in the path of the robot and then ask the students how many steps that robot needs to take to reach the placed object. In this way we work on the ability to estimate distances and to achieve this we can use the methodology of based challenge learning by involving students on distance estimation.

- Prospective teachers get into groups and design a similar learning activity. Then groups share their learning activities and discuss how they can improve their applications and use robots to teach distance estimation.

<u>Time estimation</u>

- Prospective teachers will examine the example learning activity below to learn how to teach time estimation.

Example Learning Activity

- This is something that can be complex for very young students (6-7 years old) and therefore they need to visualise what is happening in time by *counting both verbally and with their hands* (embodiment strategy) while also having a digital timer.
- How to give physicality to time which is by definition an abstract concept? To do this, we can use a robot (such as MBot or Lego WeDo2) or block programming software such as Scratch Jr. The next step is to program the robot to *move in a straight line for twenty seconds*. This is very interesting because it links time to distance and therefore implicitly works on the concept of speed.
- After having programmed the robot, we will start it up and, at the same time as the robot starts up, we will start the timer and the students will have to count the seconds out loud in order to obtain a relationship between the various data.
- At this point we can carry out different types of estimation. For example, keeping the speed of the robot constant, we could ask students how far it covers in ten seconds and make predictions about the estimated time and distance. In this case, we can also work on the concept of multiples.
- We will conclude the work by increasing the difficulty through the power of the robot. By doubling the power of the robot and consequently the speed, the same amount of space that was previously covered in twenty seconds will now be covered in ten seconds.

    - Obviously, due to friction and other external factors, students need to be reminded to use a good degree of approximation.
- Prospective teachers will get into groups and design a new similar learning activity. Then groups will share their learning activities and evaluate their applicability.

Resources:

Paper, carboard, coloured pencils, markers
Rulers, rope, lanyard
Paper adhesive tape to build maze on the floor
Educational Robots (Blue Bot, mTiny, etc.)
Plasticine and other artcrafts materials (to represent streets, buildings).
Robotics kits.

Assessment Tools:

- Self-assessment is required to determine individual's assessment of own progress
- Writing an essay is essential for understanding the group processes
- Rubric evaluation is used for evaluating the designed activities
- Peer assessment: A prospective teacher simulates lecturing a colleague as if he were a child.

Theoretical Knowledge

Many researches on Math for primary school recommend Math teaching supported by technology. Math learning should be done while using instructional media, particularly visual learning media, with the support of technology-based ecosystem environments. (Bellas et al, 2019). The implementation of visual and technological resources has had good results in the teaching-learning process of Mathematics.

Numerous studies have been conducted on technology applied to the teaching of Mathematics (Fabian et al, 2018) allowing to conclude that cognitive, affective, and metacognitive factors can be modelled and supported by intelligent tutoring systems, not only on the cognitive aspect, but also on other elements, such as motivation and confidence.

The educational approach based on developing logic and creativity in new generations since the first stage of education is very promising. To these aims, the use of robotic systems is becoming fundamental if applied since the earlier stage of education. In primary schools, robot programming is fun and therefore represent an excellent tool for both introducing to ICT and helping the development of children's logical and linguistic abilities of children. (Scaradozzi et al., 2015).

Moreover, learning robots programming also becomes an opportunity for primary school pupils for developing their linguistic and logical skills, always focusing on pedagogical rather than technological issues.

The first and main aim of this project concerns the introduction of Robotics at the Primary school supporting Math learning is not teaching them to program a machine per se, but to consider robotics as a normal method of work rather than an exceptional way of operating.

In her book, Coding as a playground (Bers 2018), Marina Bers suggest seven powerful ideas for using educational robotics and computational think in early education. These phases are also the grid of this Lesson 2, that contains all the elements of learning, from curiosity and gico to self-assessment and debugging.

Algorithms: Identifying what constitutes a step in the sequence promotes abstract thinking. In the lesson this breakdown of actions in sequence is clearly required

Modularity: breaking down tasks or procedures into simpler units, engaging in decomposition. What tasks are involved in my problem? How small should by my task to be sure I carry out my mission?

Control structures: the order in which instructions are followed or implemented. But the key issue in the early childhood is familiarization with patterns and realizing the relationship between cause and effect e.g. when the robot has to torn because of the angle as programmed, or when the robot encounter an obstacle.

Representation: order and manipulate data and values in different ways. Concepts can be represented by symbols e.g. letters can represent sounds, numbers can represent quantities, programming instructions can represent behaviours. Different types of things have different types of attributes. For instance, robot intelligence works differently from our, or from a cats' mind. And data types have different functionalities e.g. numbers can be added, letters can be strung together. In coding, we need to understand that programming languages use symbols to represent actions.

Hardware/software: computing systems need hardware and software to operate. The software provides instructions to the hardware. Robots are mainly visible hardware but some components might be hidden e.g. circuit boards. Children need to understand that hardware is programmed to perform a task and that many devices can be programmed, not just computers.

Design process: an iterative process used to develop programs and tangible artifacts. The design process is a cycle: there is no official starting or ending point. The steps are: ask, imagine, plan, create, test, improve, and share.

Debugging: the need to fix our programs using testing, logical thinking and problem solving. Once children understand how to debug their systems, they start to develop common troubleshooting strategies that can be used on a variety of computing systems. Things do not just happen to work at the first attempt, but many iterations are usually necessary to get it right.

Evaluation: May be self-assessment based on feedback; and/or peer assessment, if in collaboration with a mate. Or democratic group evaluation: children in the group come together to evaluate the mission.

LESSON 4

Subject: Pattern Recognition

Unplugged Phase

Unplugged robotics usually use cards to define the movements of a character. Each card, with an unambiguous drawing has a clear meaning, that is a basic instruction to create a code for the character's movements. Unplugged Cards are often used placing the characters on a printed or physically built grid, and each movement card usually means "move one step", so onto the next position on the grid.

Duration: 2 lesson hours

Learning Outcomes:

- To realise that children are able to estimate how a given sequence will continue
- To realise that children can engineer objects
- To learn how to teach students to move in different directions, at different speeds
- To learn how to teach students to avoid obstacles
- To learn how to teach students to work independently in own space
- To learn how to teach students to follow a leader
- To learn how to teach students to recognise pattern (geometry)
- To learn how to teach students to program the robotics kit (sums, subtraction, multiply, division).

Teaching Methods: Discussion, flipped learning, lecture, question-answer, brainstorming, collaborative learning

Learning-Teaching Process:

Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- Prospective teachers examine the learning activity described below. They learn how to apply this activity during their internship.

Example Learning Activity

- Two different objects are given to the children. An alternate sequence of the objects (i.e. square, circle, square, circle, square, circle, …), is shown to children (using the physical objects or a photograph of them). Teacher asks children to guess what the next object in the sequence should be.
- Children produce a line and a circle on the floor with sticky tape (measure, length, direction).
- Children count each other and decide how to divide the space between them (Addition, Division)
- Each child has a piece of equipment to hold like a steering wheel / or a hoop that the children can stand inside and hold it around their waist to give the idea that they are in a car. They can also hold the hoop or steering wheel in front of them.
- Children start on their own marker and then learn to move around the play space slowly not bumping into each other, using the equipment as a steering wheel.
- Once they are familiar with this you can introduce instructions, given to children in form of lights or colored tags
- RED – the children stop
- ORANGE the children jog/march on the spot
- GREEN the children move freely around the play space
- PINK: Children move on a straight line
- YELLOW: Children move in a circle.
- For this activity, you can use a wide range of objects, for example: construction bricks, wooden blocks, printed images, puzzle parts and so on.
- You can also use printed worksheets.

The Plugged Phase

- This unplugged lesson is then carried over with robots, working on pattern recognition. E.g., the teacher programs *in primis* a robot to walk a perimeter, e.g., a rectangle, and the children must guess the pattern.
- Then the teacher changes the pattern, a circle, then a simple line (to get children used to unexpected and surprise), and so on.
- Then the children themselves learn how to program the robot to follow the patterns.

Resources:
Paper, carboard, coloured pencils, markers
Rulers, rope, lanyard
Paper adhesive tape to build maze on the floor
Educational Robots (Blue Bot, mTiny, etc.)
Plasticine and other artcrafts materials (to represent streets, buildings).
Robotics kits.

Assessment Tools:

- Self-assessment is required to determine individual's assessment of own progress
- Writing an essay is essential for understanding the group processes
- Rubric evaluation is used for evaluating the designed activities
- Peer assessment: A prospective teacher simulates lecturing a colleague as if he were a child.

Theoretical Knowledge

(Pattern recognition in Real Life and in Maths)

The education system should create an opportunity for students to represent, listen, and discuss mathematical ideas in different ways and contexts. Furthermore, the education system not only should provide an environment for students to connect mathematical ideas to each other, but also should simulate the real world situation and provide an opportunity for students to experience problem solving, social skills, and attitudes that are used in the real world.

The ability of pattern recognition, fundamental in mathematics (number theory, multiplication tables, identification of series, etc.) is fundamental in every aspect of life, school and life in general. Recognizing patterns means understanding similarities, differences, sequences in various fields, not least social relations.

The teacher could illustrate this concept with various examples from life in the school and family and connect them to mathematics. In this way, she/he help students to see mathematics as a "useful, interesting and lively discipline, and encourage them to actively engage in the class.

Without engagement, learning hardly occurs. Teacher learning is not an exception. To learn to teach STEM, teachers ought to engage in the learning process. The first step in this lesson is to engage college students in imagining patterns in life and transposing them into small mathematics exercises.

There has been a little research on how to engage primary teachers in the process of STEM learning for teaching. Adams, Miller, Saul, and Pegg (2014), primary teachers engaged in using the connection between students and their local, real-world environments, called a place-based education approach, to teach mathematics, science, and social studies. As a result, their confidence in STEM teaching and intent to teach STEM increased.

Di Francesca, Lee, and McIntyre (2014) described a primary teacher preparation program in which the engineering design process was integrated into mathematics and science teaching courses.

Integrative learning and teaching of STEM is crucial and robotics enables interdisciplinary work (Bers, 2008). Robotics is a motivating, learning tool due to its encouragement of experiential, hands-on learning (Mataric, Koenig, Nathan,&Feil-Seifer, 2007).

Robotics can be effective in teaching STEM because it enables real-world applications of the concepts of engineering and technology and helps to remove the abstractness of science and mathematics (Nugent et al., 2010)

The common contexts in which robotics has been implemented with K-12 students are summer and afterschool programs. Competitions also have been a popular context that involves many interested students in robotics activities. However, such contexts tend to attract students who are already motivated to learn STEM. To engage more students in STEM learning, there is a need to approach students who are not interested in such extracurricular opportunities as well as those who are interested but cannot afford such opportunities. Thus, connecting robotics activities to curricular goals in classrooms should expand benefits of robotics for STEM education.

LESSON 5

Subject: Using robots to explore math concepts with children 6-8 years old.
Duration: 2 hours
Learning Outcomes:

- To explore problem-based learning to work with robotics and deal with math anxiety
- To understand the importance of working with unplugged and plugged activities to promote computational thinking
- To pinpoint math curricular subjects to design teaching learning activities with robots
- To explore and recognize the use of robots to foster learning about location and orientation in space, geometric figures, distance and length and addition and multiplication
- To reflect on the different didactic approaches to work with robots with children aged 6-8 years old.

Teaching Methods: Collaborative work, hands on activities, discussion and reflection, research
Learning-Teaching Process:
Before the Classroom Time, prospective teachers use the online teaching materials to learn about the topic.

In-class Activities

- Students will explore, analyse, and evaluate a set of activities based on a problem-based approach.
- The proposed resources for this task are an educational robot (e.g. Bee-Bot, Robot Doc), robot mat with grid, brown cardboard (to represent the garden beds) and plasticine and other materials (to represent the vegetables).

- An activity sheet number 2 design for children with 5-7 years old. All the activities will answer the challenge of plan and design a vegetable garden and to develop the best strategies to care for it.
- Students will be organized in small groups.
- Explore the activity and to perform all the tasks.
- Pinpoint the math objectives and contents that can be explored with the vegetable garden activities.
- Identify unplugged and plugged activities and reflect about their didactical potential.
- Reflect on the potential of robotics and real-life scenarios for learning mathematical topics such as addition, multiplication, measurement or geometric shapes and design possible didactic approaches.
- Discuss and plan what can happen in each task, the learning that can emerge in each topic, the time for each one, the way the children work, possible resolutions or difficulties and the way how they can promote discussion of the main results with the whole class.
- Students will be invited to synthesize these ideas, filling a table with the elements for each activity task:

Task	**Activity type**	**Objectives**	**Contents**	**Duration**

- Discuss strategies to explore the activities with children.
- Discuss possible solutions and children's difficulties to perform the tasks.
- Explore connection and multidisciplinary opportunities
- Propose extensions of the tasks and other scenarios to use robots to teach math
- Discuss how to evaluate the children's performance.

Assessment Tools:

- Reflective report oriented by didactic, curricular, or content issues and corresponding discussion.
- *What mathematical content can you identify in the proposal? How does that connect with the curriculum in your country?*
- *How do you think students would solve the different steps of the activity? Where do you think your students would have difficulties? How could you support them in overcoming them?*
- *How could you make the activity engaging for your students?*
- *Can you think of a way for the students to present their work to the class? How would that support their mathematical learning?*
- *Which strengthens and weaknesses do you see in this activity in terms of mathematical learning? And in terms of robotics in primary education?*

Theoretical Information

In this session, the main aim is to analyze curricula math topics and learning scenarios from the work of children of 6-8 years in the task Green Garden.

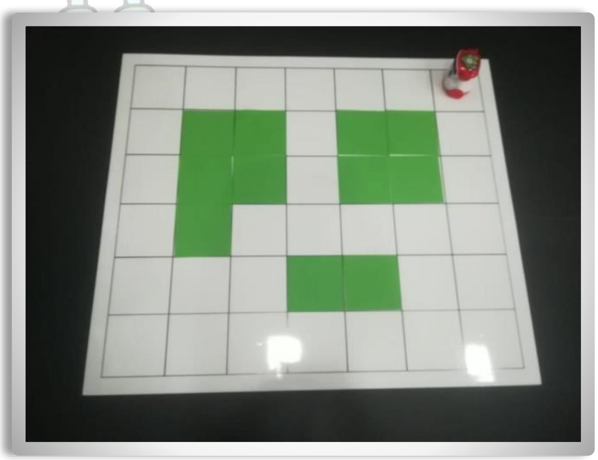
The task Green Garden aims to plan and design a vegetable garden, planting a vegetable garden and watering a vegetable garden.

In this session, it is important that the future teachers recognize the main learning outcomes for the children with the task such as

- Analyse and describe spatial relationships, standing in space in relation to others and objects.
- Perform progressive and regressive counting.
- Recognize basic facts of addition using different strategies that mobilize numerical relationships and properties of operations.
- Recognize basic facts of multiplication using different strategies that mobilize numerical relationships and properties of operations.
- Describe flat shapes, identifying their properties.
- Compare distances between pairs of objects and points.
- Compare lengths and properties of geometric equality.
- Know and apply strategies to solve problems with natural numbers.
- Explain ideas and processes and justify mathematical results.
- Express mathematical ideas and processes, orally and in writing, using their own language and vocabulary.

It is important that future teachers recognize that this task enables to identify, interpret and describe spatial relationships, placing themselves in space in relation to others and objects, identify and characterize properties of geometric figures and to develop an interest in mathematics and appreciate its role in the development of other sciences and fields of human and social activity.

To support didactic analysis can be used a diagram as the follows in the picture that represents an example of vegetable garden with three beds to plant parsley, carrot, and lettuces.



Examples of possible answers and reflection for each task:

Task	Activity type	Objectives	Contents	Duration

1. Plan your vegetable garden on the mat, using brown cards, to build your garden beds. Smaller beds for aromatic plants and bigger ones for other vegetables such as lettuce or cabbage. Your planning should be like a "top view" of your vegetable garden. Identify the geometric shapes in your vegetable garden and explaining the properties of each of the geometric shapes.	Unplugged Activity	Identify, interpret and describe spatial relationships, placing themselves in space in relation to others and objects. Describing plane figures, identifying their properties. Express mathematical ideas and explain reasoning, procedures and conclusions.	Location and orientation in space. Geometric shapes.	20 minutes

This request leads the children to compose and decompose plane figures in a logic of "paving" a space that serves as a basis for the creation of the vegetable garden. The teacher should encourage the children to identify and compare the figures chosen for each space.

An interesting proposal may be to ask each child/group to describe their construction, without showing it, and then colleagues guess how that space is organised. This allows children to develop their visualization skills and to understand the properties of geometric figures, interpreting and describing spatial relationships.

Some difficulties may arise in describing and identifying spatial relationships when communicating ideas that are not thought of in relation to one's own body.

It is also important to note that we are talking about plane figures since we are looking at the top view of the garden, the floor plan. Otherwise, two-dimensional figures only "exist" in projections or views of 3D objects in our life. This may help clarify the usual incorrectness of saying that a field is a rectangle or that a ball (sphere) is a circle.

Task	Activity type	Objectives	Contents	Duration
2. Program the robot so that it can outline each of the vegetable beds.	Plugged Activity	Identify, interpret and describe spatial relationships,	Location and orientation in space	40 minutes

Predict and record the sequences of actions of the robot, using arrows such as the following:  Move on  Turn right  Turn left  Move backwards Confirm your estimate by placing the robot around each figure. Compare the code you used with the properties of the geometric shapes the robot outline.		placing themselves in space in relation to others and objects. Design and apply strategies in solving problems involving properties of geometric figures in the plane and evaluate the plausibility of the results. Express mathematical ideas and explain reasoning, procedures and conclusions.	Geometric shapes	

The children should start by calculating the length measure of each move "move on" and "move backwards" of the robot and then estimate the length measure of each side of the figures. After recognising the properties of the geometric figures, they plan the movement of the robot to go around each of them.

Again, it is possible that children may have difficulties communicating the turn right and turn left movements, mainly because the left and right of the robot's movement may not correspond to the left and right of their own body. In this case, it is important that the children stand in such a way that the movement of the robot corresponds to the movement of their body, simulating the path on the side of each figure.

Comparing the code designed to go around each figure is also an important idea of the task, because may be different sequences but geometrically equivalent sequences that result in equivalent algorithms.

Task	Activity type	Objectives	Contents	Duration
3. Now let's plan how many plants we can plant in your	Unplugged Activity	Recognise numerical relationships and	Arithmetic operations	30 minutes

garden, knowing that in each grid of your mat you can only plant one vegetable. Explain how you calculated the number of plants.		properties of operations and use them in calculation situations. Compare and order numbers, and make plausible estimates of quantities and of sums, differences and products, with and without the use of concrete material. Express mathematical ideas and explain reasoning, procedures and conclusions.		

In this task children are expected to count plants in different ways, using addition, subtraction or multiplication. It's a proposal that can lead to the use of basic facts of operations in calculation situations and to the understanding of properties of operations (e.g., the commutative property of addition and multiplication, distributivity of multiplication with respect to addition or multiplication as addition of equal parts).

It can be a good opportunity to consolidate number compositions and decompositions, also through subitizing.

Task	Activity type	Objectives	Contents	Duration
4. The robot will help you to plant your vegetable garden. Program your robot to outline the beds and to plant / sow your vegetables. What is the length of the line that the robot travels around each of the vegetable beds? Can you	Plugged Activity	Compare and order objects according to the length and measure them using conventional or non-conventional units of measurement. Design and apply strategies in solving	Measurement	30 minutes

estimate its value in grid units and in cm? What is this length called?		problems involving visualisation and measurement and evaluate the plausibility of the results.		

This task allows work on estimating length measures by spatial visualisation. Furthermore, it is important to stimulate the comparison of results involving the use of different units of measurement.

Task	Activity type	Objectives	Contents	Duration
5. The robot will now help you to water your garden. Place a watering point on each bed and program the robot to circulate through the garden to activate the irrigation system. Start by predict and record the sequences of actions of the robot, using arrows (as in the previous question). If the robot has to go through all irrigation points, how far will it travel? Compare your course with the course of other colleagues. How far is the shortest route? Can you explain how to choose the shortest path that robot should follow? Explain your reasoning.	Plugged Activity	Compare and order natural numbers, estimate the result of operations and assess their reasonableness. Recognise and describe regularities in sequences or in numerical tables, formulate conjectures and explain how these regularities are generated. Compare and order objects according to the length and measure them using conventional or non-conventional units of measurement. Design and apply strategies in solving problems involving visualisation and measurement and evaluate the plausibility of the results.	Natural numbers. Arithmetic operations. Measureme nt.	40 minutes

		Express mathematical ideas and explain reasoning, procedures and conclusions.		

Apart working location and spatial orientation, the children study different routes and compare the lengths travelled by the robot in each resolution.

In this request, the robot travels a longer distance with a path that corresponds to a similar geometric figure, since the path has to be made outside the polygonal line of each figure. Defining this new path, the children have to program the robot for at least one more "Move on" movement relative to each side of the geometric figure.

The proposal of defining a conjecture that leads them to the shortest possible route allows the discussion of different algorithms and their optimization. For example, children can present a strategy close to the logic of the well-known "greedy algorithm" (problem-solving heuristic of making the locally optimal choice at each stage).

Green Garden | Activity Set 2

1. Plan your vegetable garden on the mat, using brown cards, to build your garden beds. Smaller beds for aromatic plants and bigger ones for other vegetables such as lettuce or cabbage. Your planning should be like a "top view" of your vegetable garden.

Identify the geometric shapes in your vegetable garden and **explaining the properties** of each of the geometric shapes.

2. Program the robot so that it can outline each of the vegetable beds.

Predict and record the sequences of actions of the robot, using arrows such as the following:

Move on

Turn right

Turn left

Move backwards

Confirm your estimate by placing the robot around each figure.

Compare the code you used with the properties of the geometric shapes the robot outline.

3. Now let's plan **how many plants we can plant in your garden**, knowing that in each grid of your mat you can only plant one vegetable**. Explain how you calculated** the number of plants.
4. The robot will help you to plant your vegetable garden. **Program your robot** to outline the beds and to plant / sow your vegetables.
What is the **length of the line that the robot travels** around each of the vegetable beds? Can you **estimate its value** in grid units and in cm? What is this **length called**?
5. The robot will now help you to water your garden. Place a watering point on each bed and **program the robot** to circulate through the garden to activate the irrigation system.
Start by predicting and **recording the sequences of actions of the robot**, using arrows (as in the previous question).
If the robot has to go through all irrigation points, **how far will it travel**? **Compare** your course with the course of other colleagues. How far is the shortest route?
Can you **explain** how to choose the **shortest path** that robot should follow? Explain your reasoning.

LESSON 6

Subject: Practicing and reflecting. Green Garden 8-10 years
Duration: 2 hours
Learning Outcomes:

- To explore problem-based learning as a way to work with robotics and deal with math anxiety
- To understand the importance of working with unplugged and plugged activities to promote computational thinking
- To pinpoint math curricular subjects to design teaching learning activities with robots
- To explore and recognize the use of robots to foster learning about location and orientation in space, geometric figures, distance and length and arithmetic operations
- To reflect on the different didactic approaches to work with robots with children aged 8-10 years old

Teaching Methods: Collaborative work, hands on activities, discussion and reflection, research.
Learning-Teaching Process:
<u>Before the Classroom Time,</u> prospective teachers use the online teaching materials to learn about the topic.

<u>In-class Activities</u>

- Students will explore, analyse and evaluate a set of activities based on a problem-based approach.
- The proposed resources for this task are an educational robot (e.g. Mbot), robot mat with grid, brown cardboard (to represent the garden beds), plasticine and other materials (to represent the vegetables) and humidity and temperature sensors.
- All the activities will answer the challenge of plan and design a vegetable garden and to develop the best strategies to care for it.
- Students will be organized in small groups.
- Explore the activity and to perform all the tasks.

- Pinpoint the math objectives and contents that can be explored with the vegetable garden activities.
- Identify unplugged and plugged activities and reflect about their didactical potential.
- Reflect on the potential of robotics and real-life scenarios for learning mathematical topics such as addition, multiplication, measurement or geometric shapes and design possible didactic approaches.
- Discuss and plan what can happen in each task, the learning that can emerge in each topic, the time for each one, the way the children work, possible resolutions or difficulties and the way how they can promote discussion of the main results with the whole class.
- Students will be invited to synthesize these ideas, filling a table with the elements for each activity task:

Task	Activity type	Objectives	Contents	Duration

- Discuss strategies to explore the activities with children.
- Discuss possible solutions and children's difficulties to perform the tasks.
- Explore connection and multidisciplinary opportunities.
- Propose extensions of the tasks and other scenarios to use robots to teach math.
- Discuss how to evaluate the children's performance.

Assessment Tools:

- Reflective report oriented by didactic, curricular, or content issues and corresponding discussion.
- *What mathematical content can you identify in the proposal? How does that connect with the curriculum in your country?*
- *How do you think students would solve the different steps of the activity? Where do you think your students would have difficulties? How could you support them in overcoming them?*
- *How could you make the activity engaging for your students?*
- *Can you think of a way for the students to present their work to the class? How would that support their mathematical learning?*
- *Which strengths and weaknesses do you see in this activity in terms of mathematical learning? And in terms of robotics in primary education?*

Theoretical Information

In this session, the main aim is to analyse curricula math topics and learning scenarios from the work of children of 8-10 years in the task Green Garden.

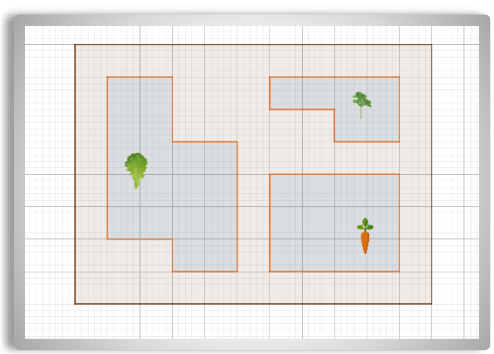
The task Green Garden aims to plan and design a vegetable garden, planting a vegetable garden and watering a vegetable garden.

In this session it is important that the future teachers recognise the main learning outcomes for the children with the task such as

- Analyse and describe spatial relationships, standing in space in relation to others and objects.
- Perform progressive and regressive counting.
- Recognize basic facts of addition using different strategies that mobilize numerical relationships and properties of operations.
- Recognize basic facts of multiplication using different strategies that mobilize numerical relationships and properties of operations.
- Describe flat shapes, identifying their properties.
- Compare distances between pairs of objects and points.
- Compare lengths and properties of geometric equality.
- Know and apply strategies to solve problems with natural numbers.
- Explain ideas and processes and justify mathematical results.
- Express mathematical ideas and processes, orally and in writing, using their own language and vocabulary.

It is important that future teachers recognise that this task enables to identify, interpret and describe spatial relationships, placing themselves in space in relation to others and objects, identify and characterise properties of geometric figures and to develop an interest in mathematics and appreciate its role in the development of other sciences and fields of human and social activity.

To support didactic analysis can be used a diagram as the follows in the picture that represents an example of vegetable garden with three beds to plant parsley, carrot and lettuces.



Example of vegetable garden with three beds to plant parsley, carrot, and lettuces.

Examples of possible answers and reflection for each task:

Task	Activity type	Objectives	Contents	Duration

1. Plan your vegetable garden on the mat, using brown cards, to build your garden beds. Smaller beds for aromatic plants and bigger ones for other vegetables such as lettuce or cabbage. Your planning should be like a "top view" of your vegetable garden.	Unplugged Activity	Identify, interpret, and describe spatial relationships, placing themselves in space in relation to others and objects. Describing plane figures, identifying their properties. Express mathematical ideas and explain reasoning, procedures and conclusions.	Location and orientation in space Geometric shapes.	10 minutes

This task leads the children to compose and decompose plane figures in a logic of "paving" a space that serves as a basis for the creation of the vegetable garden.
It's important to note that we are talking about plane figures since we are looking at the top view of the garden, the floor plan. Otherwise, two-dimensional figures only "exist" in projections or views of 3D objects in our life. This may help clarify the usual incorrectness of saying that a field is a rectangle or that a ball (sphere) is a circle.

Task	Activity type	Objectives	Contents	Duration
2. Identify the geometric shapes in your vegetable garden and explaining the properties of each of the geometric shapes.	Unplugged Activity	Identify, interpret and describe spatial relationships, placing themselves in space in relation to others and objects. Identify properties of plane figures and make classifications, justifying the criteria used. Design and apply strategies in solving problems involving properties of geometric figures in the plane and	Location and orientation in space Geometric shapes.	20 minutes

		evaluate the plausibility of the results. Express mathematical ideas and explain reasoning, procedures, and conclusions.		

This task is a good opportunity to recall the concept of polygon and its relationship to that of geometric figure and the properties associated with each.

Also in this level, an interesting proposal may be to ask each child/group to describe their construction, without showing it, and then colleagues guess how that space is organised. This allows children to develop their visualisation skills and to understand the properties of geometric figures, interpreting and describing spatial relationships. It is possible that the children don't show any difficulty in describing the geometric figures that represent each of the spaces, at least characterized in terms of the measure of their area, but they may feel some difficulty in describing the geometric figures (more if they are not regular), the relative position of each one in relation to the others and in relation to the figure that represents the total space reserved for the vegetable garden.

Task	Activity type	Objectives	Contents	Duration
3. Now let's plan how many plants we can plant in your garden, knowing that in each grid of your mat you can only plant one vegetable. Explain how you calculated the number of plants.	Unplugged Activity	Recognise numerical relationships and properties of operations and use them in calculation situations. Compare and order numbers, and make plausible estimates of quantities and of sums, differences, and products, with and without the	Arithmetic Operations	15 minutes

		use of concrete material. Express mathematical ideas and explain reasoning, procedures, and conclusions.		

In this task children have to study what is the ideal space to plant each one plant and then, they are expected to count plants in different ways, using the basic arithmetic operations according to the free space. It's a proposal that can lead to the use of basic facts of operations in calculation situations and to the understanding of properties of operations (e.g. the commutative property of addition and multiplication, distributivity of multiplication with respect to addition or multiplication as addition of equal parts).

Task	Activity type	Objectives	Contents	Duration
4. Find out the cost of planting each plant and according to your vegetable garden estimate the profit that can be made by selling the plants over a period of time (for example one year).	Unplugged Activity	Recognise numerical relationships and properties of operations and use them in calculation situations. Compare and order numbers, and make plausible estimates of quantities and of sums, differences and products, with and without the use of concrete material. Express mathematical ideas and explain reasoning, procedures, and conclusions.	Arithmetic operations Measurement	15 minutes

With this task, students find out the cost of planting each plant and its maintenance cost and estimate the profit to be made from selling the produce after a period of time.

It might be interesting to ask students how much profit they could make if the cost of planting is less (e.g. half). This task can also be a good opportunity to establish conjectures that relate shapes and areas of each planting section to the profit to be made in each situation (e.g. working on optimising space to ensure a greater number of plants in each section).

Different forms of profit (without being proportional to the unit) can also be discussed when the quantity of a certain product for sale is higher than a certain value.

Task	Activity type	Objectives	Contents	Duration
5. Calculate the perimeter and the area of each region of your vegetable garden and explains your reasoning. Is it possible two regions with the same area have different perimeters? Justify your reasoning. Estimate the distance the robot would travel if it went around each region and compare it to the perimeter of each part. Explain your reasoning.	Unplugged Activity	Compare and order natural numbers, estimate the result of operations and assess their reasonableness. Measure areas using and relating SI units of measurement and make estimates of measurements. Design and apply strategies in solving problems involving visualisation and measurement and evaluate the plausibility of the results. Express mathematical ideas and explain reasoning, procedures, and conclusions.	Arithmetic operations Geometry and Measurement.	15 minutes

The students calculate the areas of each polygon representing each of the sections and can do so directly (using the unit of area measurement of the grid as in the example), by decomposing polygons and their area measure relationships or by applying the area expression (if known). If different models of vegetable gardens have been created at this stage, the students can now relate the area of each region to the area of the region to plant the same vegetable in other colleagues' garden, compare the number of plants in each and the respective profit.

They can also estimate the total space of the garden that was left available (without any planting) and compare, if possible using non-negative rational numbers, the measurements of the areas of the different parts (planted and unplanted).

Can be made, also, an investigation on the relationship between the area and the perimeter of geometric figures. Students should be able to understand that geometric figures can have equal perimeter measures and different area measures, or different perimeter measures and equal area measures.

Students should understand that the length of the path that the robot has to travel is always greater than the perimeter of the figure representing each of the regions. Whenever possible, they can even find a relationship between the length of the robot's path and the measurement of the perimeter. For instance, if the geometric figure representing a certain section of the vegetable garden is enclosed by a polygonal line with 90 degree angles and convex angles, it is easy to justify that the distance travelled by the robot will always be equal to the measure of the perimeter of the geometric figure plus twice the distance the robot travels from the boundary of the region, for each vertex of the figure (for each movement of change of direction).

For example, in region to plant carrots from the example, if

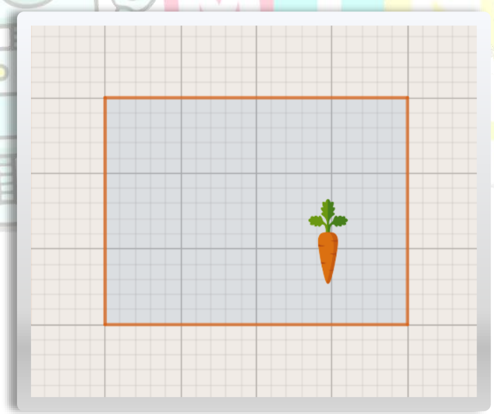


Figure: Part of vegetable garden to plant carrot

If the measurement of the perimeter is equal to 70 units of length, and the distance the robot will travel to keep a certain and constant distance from the region is, for example, 2 units of length all around the perimeter, the distance the robot will travel is equal to 70+(4*4) =70+16=86 units of length.

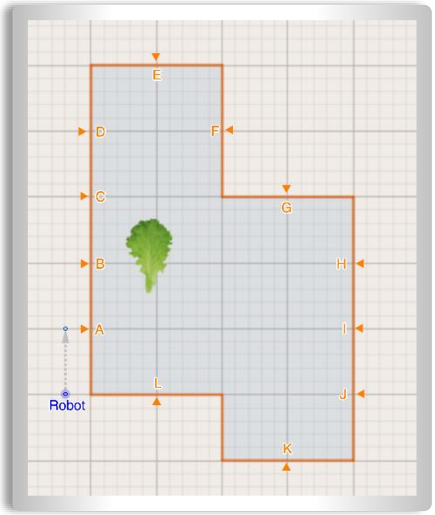
Task	Activity type	Objectives	Contents	Duration
6. The robot will help you to plant and take care your vegetable garden.	Plugged Activity	Compare and order natural numbers, estimate the result	Arithmetic operations	40 minutes

Program your robot to outline the beds and to plant / sow your vegetables. On the perimeter of each region, define points where you will measure the relative humidity of the soil. The robot will now walk on each side of each region while you measure the relative humility of the soil at the points you have defined. To do this, - set the robot to start at each vertex of each polygon and program it to travel along the paths on each side and stop at the fixed points (after stopping at each point, the robot should rotate towards the interior of the region); -measure the relative humidity of the soil with a sensor and record the data in a table, for several times during each day.		of operations and assess their reasonableness. Measure areas using and relating SI units of measurement and make estimates of measurements. Design and apply strategies in solving problems involving visualisation and measurement and evaluate the plausibility of the results. Express mathematical ideas and explain reasoning, procedures and conclusions.	Measurement.	

On the perimeter of each region, students start by defining points in each side of polygons where the robot stop to they measure the relative humidity of the soil.

This task allows work on estimating length measures by spatial visualisation. So, firstly, the students can try to estimate each distance to be travelled by the robot, without using any measurement system.

In the proposed example, next figure, Robot represents the starting point of the robot on one side of the vegetable garden region to plant lettuce and the other blue point the first stopping point for the first relative humidity of the soil measurement, at A. The remaining points B - L are possible points where the robot stops for reading the relative humility of the soil.



Movement of the Mbot and
starting point and stop to measure
relative humidity of the soil

Before programming the mbot robot for this movement, in the MBlock software, students should do tests to understand how a given power for a given time (in seconds) allows the robot to travel through a given space. In this case, it is only a movement without any change of direction, only with a stop in a certain place.

Also as was done to test the movement of the mbot, the students should experiment to find the power to turn left and right that allows the robot to be in a 90 degree position relative to the original movement.

After measuring the relative humidity, the robot should be programmed so that the turning movement that allows it to continue the movement is the opposite of the first one (if before the mbot turned to the left, then it should turn to the right and vice versa).

To measure the relative humidity of the soil, students can use sensors such as the PASCO and record the values in a table and then analyse the evolution over a period of time, trying to justify the differences and the care that is needed for certain measures of relative humidity.

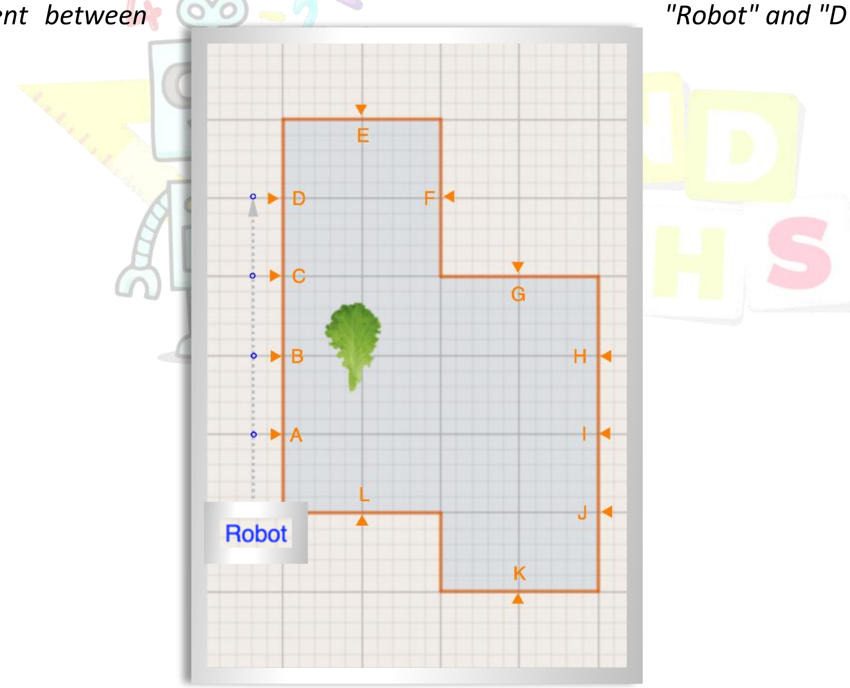
In example, suppose the distance to be travelled between A and B is 50 centimetres, i.e. each smallest line segment of the grid measures 10 centimetres.

Then, students can do some tests to understand the movement of the mbot and record in a table to find regularities. The work of numerical proportionality, even if approached by the natural errors of modelling and experimental work, is very rich work from the point of view of developing the sense of number (natural and rational non-negative).

Power	**Seconds**	**mBlock instruction**	**Approximate distance travelled**
50%	1	move forward at power 50 % for 1 secs	23 cm

25%	2	move forward at power 25 % for 2 secs	23 cm
25%	4,4	move forward at power 25 % for 4.4 secs	50 cm

By analysing the regularities, students understand, in a cumulative or proportional way, that the mbot can travel about 50 centimetres if it is programmed with 25% power to move forward for about 4.4 seconds. It might be interesting to analyse with students the combination of power with the number of seconds of movement and the space travelled. For example, for the same time, the robot movement with a power of 50% moves approximately twice as far as it would with an half power (25%).
As already mentioned, students should understand that in this kind of process the approximations and errors are very important because there are several factors that can influence the movement of the mbot (small obstacles on the ground, load of the robot power supply, small deviations of the robot direction, ...).
In the first stage, students think, now, about the algorithm for programming the robot to pass over one side of the lettuce planting area, for example (the side where the relative humidity reading points A, B, C and D are fixed). Then, students can program the robot to complete the lap over all sides of the region, stopping at points to read the relative humidity.
Robot movement between "Robot" and "D"



Movement of the Mbot and stop in A, B, C and D to measure relative humidity of the soil

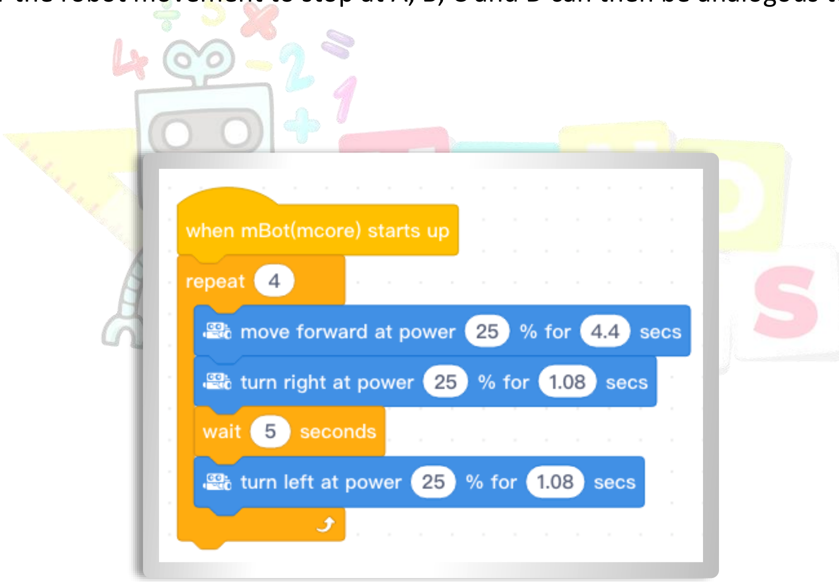
Firstly, students should predict the sequences of actions of the robot, using alternative and informal representations (natural language description or symbolic, for example) as the following:

Move on (e.g., modulus equal to the	Turn right	Turn left	Move backwards (e.g., modulus equal to the	Stop

distance between A and B)			distance between A and B)	
↑	↷	↶	↓	X

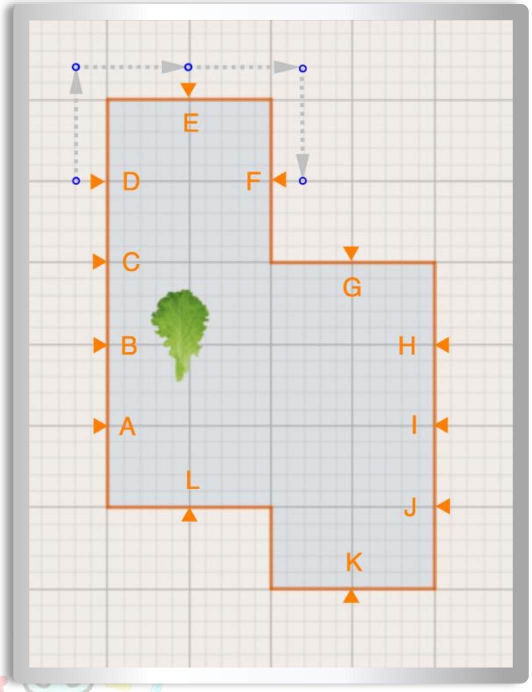
50 *cm*	**A**			50 *cm*	**B**			50 *cm*	**C**			50 cm	**D**		
↑	↷	X	↶	↑	↷	X	↶	↑	↷	X	↶	↑	↷	X	↶

The representation helps to verify that there are procedures that are repeated and therefore we can use cycles in language in MBlock.
The algorithm for the robot movement to stop at A, B, C and D can then be analogous to the following:



Robot movement between "D" and "F"

Proceeding in the same way, the students conclude that at 25% power, the mbot travels 70 cm in approximately 6.16 seconds. For example, students can calculate the time in which the robot travels 10 cm and then consider this 7 times.

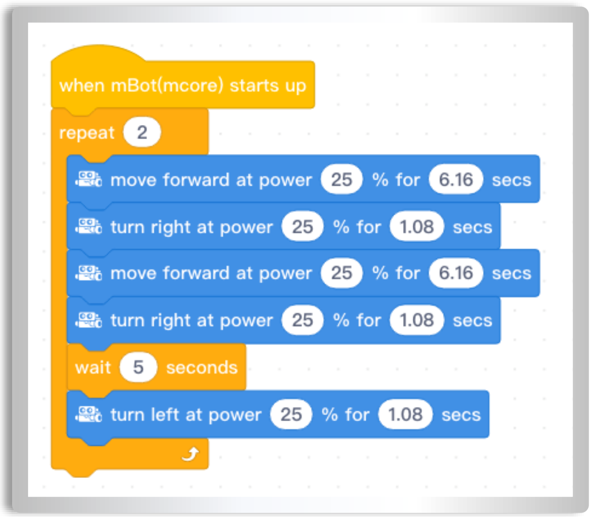


Movement of the Mbot between D and F and stop to measure relative humidity of the soil

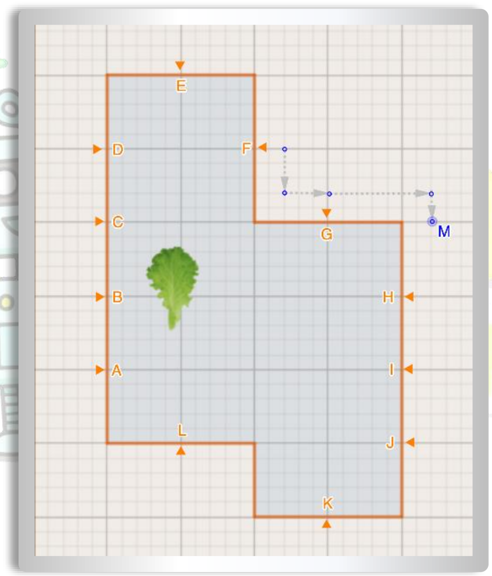
The students use symbolic representations to later program the mbot.

70 *cm*		70 *cm*	**E**			70 *cm*		70 *cm*	**F**		
				X						**X**	

In this case, we see that there are two procedures that are repeated and so students can use the cycle instruction again in programming the mbot.



Robot movement between "F" and "M"

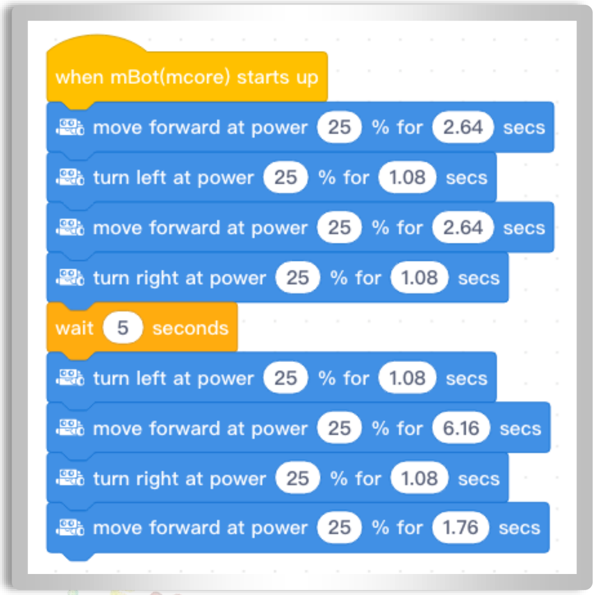


Movement of the Mbot between F and M and stop to measure relative humidity of the soil

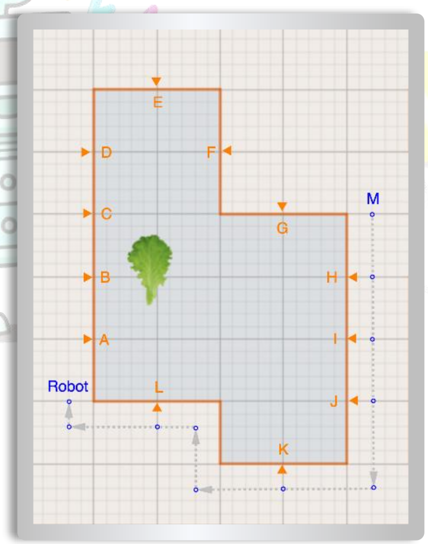
In this case, students can write:

30 *cm*	↶	30 *cm*	**G**			70 *cm*	↷	20 *cm*
⬆		⬆	↷	**X**	↶	⬆		⬆

And then,

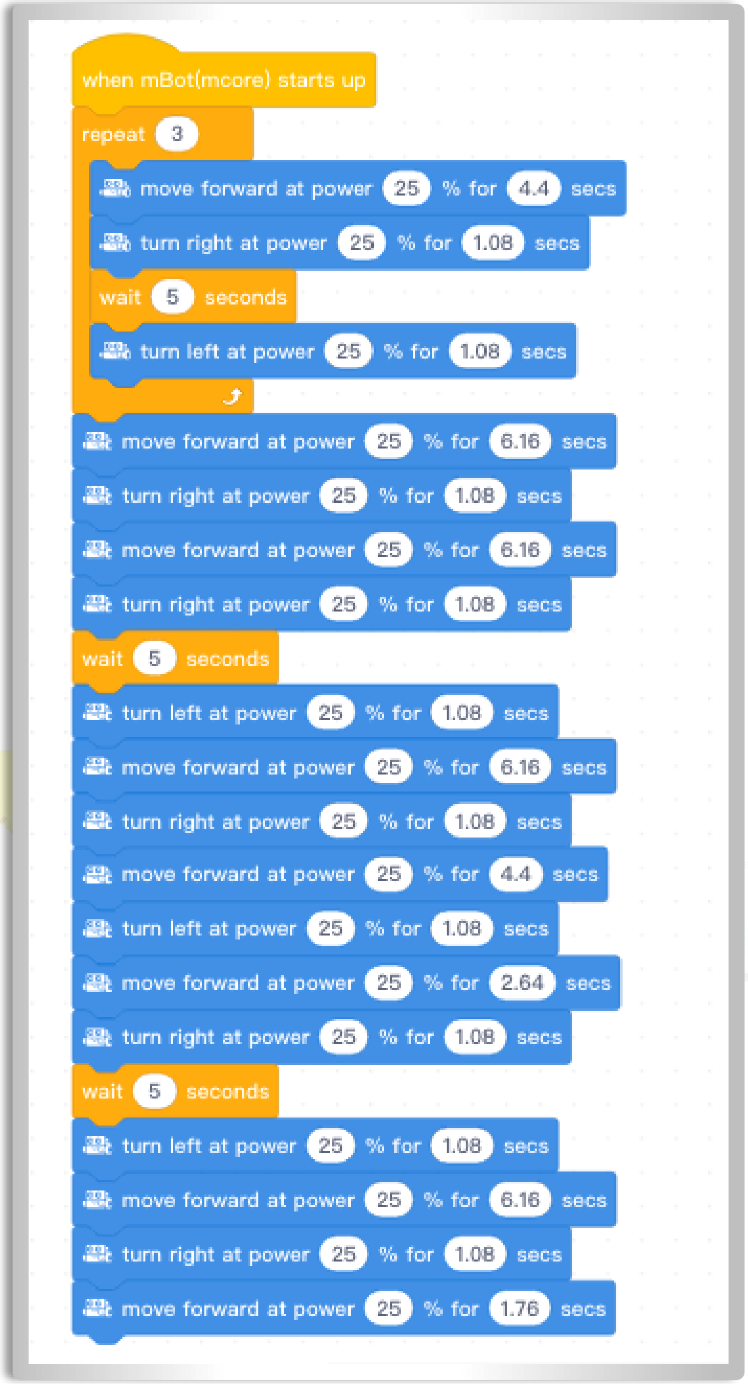


Robot movement between "M" and "Robot"



Movement of the Mbot between M and starting point and stop to measure relative humidity of the soil

The last route includes movements already used in previous parts such as the routes of 20 cm, 30 cm, 50 cm and 70 cm or the change of direction (90 degrees to the left or right).
Thus, the students program the robot for the last part of the route.



when mBot(mcore) starts up
repeat 3
move forward at power 25 % for 4.4 secs
turn right at power 25 % for 1.08 secs
wait 5 seconds
turn left at power 25 % for 1.08 secs
move forward at power 25 % for 6.16 secs
turn right at power 25 % for 1.08 secs
move forward at power 25 % for 6.16 secs
turn right at power 25 % for 1.08 secs
wait 5 seconds
turn left at power 25 % for 1.08 secs
move forward at power 25 % for 6.16 secs
turn right at power 25 % for 1.08 secs
move forward at power 25 % for 4.4 secs
turn left at power 25 % for 1.08 secs
move forward at power 25 % for 2.64 secs
turn right at power 25 % for 1.08 secs
wait 5 seconds
turn left at power 25 % for 1.08 secs
move forward at power 25 % for 6.16 secs
turn right at power 25 % for 1.08 secs
move forward at power 25 % for 1.76 secs

1. Plan your vegetable garden on the mat, using brown cards, to build your garden beds. Smaller beds for aromatic plants and bigger ones for other vegetables such as lettuce or cabbage. Your planning should be like a "top view" of your vegetable garden.

Identify the geometric shapes in your vegetable garden and **explaining the properties** of each of the geometric shapes.

2. Program the robot so that it can outline each of the vegetable beds.

Predict and record the sequences of actions of the robot, using arrows such as the following:

Move on	↑
Turn right	↷ (angle)
Turn left	↶ (angle)
Move backwards	↓

Confirm your estimate by placing the robot around each figure.

Compare the code you used with the properties of the geometric shapes the robot outline.

3. Now let's plan **how many plants we can plant in your garden**, knowing that in each grid of your mat you can only plant one vegetable**. Explain how you calculated** the number of plants.

4. Find out the **cost of planting each plant** and according to your vegetable garden **estimate the profit** that can be made by selling the plants over a period of time (for example one year).

5. Calculate the **perimeter and the area of each region** of your vegetable garden and explains your reasoning. Is it possible two regions with the same area have different perimeters? Justify your reasoning. Estimate the **distance the robot would travel** if it went around each region and compare it to the perimeter of each part. Explain your reasoning.

6. The robot will help you to plant and take care your vegetable garden. **Program your robot to outline the beds and take care of your vegetable garden.**

- On the perimeter of each region, **define points** where you will measure the relative humidity of the soil. The robot will now walk on each side of each region while you measure the relative humility of the soil at the points you have defined. To do this,

- set the robot to start at each vertex of each polygon and **program it to travel along the paths on each side and stop at the fixed points** (after stopping at each point, the robot should rotate towards the interior of the region);
- **measure the relative humidity of the soil** with a sensor and record the data in a table, for several times during each day.

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APPENDIX

LINKS TO BE USED DURING MODULE 3/LESSON 4

https://www.ejmste.com/download/the-effect-of-blended-learning-in-mathematics-course-4688.pdf

https://www.researchgate.net/publication/317851421_Blended_learning_in_teaching_mathematics_at_primary_and_secondary_school

https://www.youtube.com/watch?v=VTRriSQhs60

www.cabarrus.k12.nc.us › handlers

PRELIMINARY INFORMATION FOR MODULE 5

Why Educational Robotics in primary school?

Educational robotics (ER) is a discipline that aims at the design and application of robotics kits and coding programs for pedagogical purposes. ER is not a new application of robotics and coding, but, rather, it has been growing exponentially in recent years. It has a major impact on learning and it is associated with the STEAM disciplines (Science, Technology, Engineering, Art, and Mathematics) for the development, skills, and understanding of mathematical, physical, engineering, and related concepts (Daniela, 2019).

There is a significant and confirmed literature on the benefits of using ER, assessing that ER promotes a learning centered on the student teaching, and that it is offering to education innovative methods.

The integration and use of educational robotics in the teaching-learning process in pre-school and primary, is as a resource to address the diversity of the classroom, as a means to help the inclusion of all students, as well as keep them active and motivated (Scaradozzi et al, 2014).

Introducing students to the areas of Mathematics, through play and constructionist learning in order to generate new knowledge, is one of the goals of the usability of ER in the classroom.

Mathematics occupies a central place in the whole literacy as it is defined in our project. However,

the way it is often taught in school causes it to be perceived as a subject with no relation or at least a limited one with the real world. Integrating mathematics into STEAM allows it to be revalued by students as central elements of scientific and technological work, and always present in real life. Using integrated STEM proposals, practically all the contents of pre-primary and primary school curriculum in the area of Mathematics can be addressed and, in addition, better understood by the students (Bellas et al., 2019). These contents include not only the computational skills, but especially the bae elements of mathematics, we would say, meta-mathematical, such as

- spatial sense
- sense of time
- sense of quantity
- sense of weight
- sense of measurement

- laterality and symmetry
- use of different senses to understand the surrounding environment and sensor fusion
- ability to switch between time and length measurements, etc.
- transformations
- use of filters
- data analyzing.

As may be seen, Math's literacy involves interrelated competencies, that are intertwined and overlapping, and often, drive each other forward.

Robotic Kits Overview

There are some robots on the market that can be used in primary school, according to shape, size, function, working environment, and autonomy. Depending on the shape, there are: zoomorphic (imitation of a creature, e.g., bee), humanoid (reproduction of the shape of a human and its movements, in this case, the NAO robot), hybrid (combination of the above), and polymorphic (different shapes, adapting its structure according to the task).

Here are the kits we can recommend, for an age group between 4 and 10 years old:

Cubetto

A wooden robot, with an Arduino heart, that teaches children to program while having fun.

It's a play set consisting of a robot (Cubetto), a console, a fabric map and 16 blocks of instructions, colored tiles to be inserted into the console. These colorful tiles, distinguished by marks engraved on the sides, can be recognized by color, shape and tactile response even by visually impaired children.

Blue Bot

These cute bee-shaped robots are educational tools designed for kindergarten through elementary school students. They are able to memorize a series of basic commands and move along a path according to the recorded commands. Both Bee-Bot and Blue-Bot have all the commands on their backs: forward, backward, left and right turns. The new Blue-Bot can be used via tablet or smartphone thanks to the dedicated app available for iOS and Android. Through Bluetooth it will then be easy to send the command to the robot bee and see it executed!

Lego We Do 2.0

With the unique combination of LEGO Education bricks, icon-driven software designed for school settings, and teacher-ready projects and activities, bringing educational robotics and coding into the mainstream will be a breeze thanks to WeDo 2.0. Through hands-on construction of motorized models assembled with LEGO bricks, students are motivated to study robotics, coding, and STEM subjects and to acquire a scientific mindset. This leads them to systematically question reality, observing phenomena, making hypotheses and creating concrete solutions to problems inspired by real life. These solutions can then be documented directly on the software and then shared with the teacher, the class or a larger group.

mTiny

mTiny is an early childhood educational robot designed for children growing up in the digital age. Its unique reading pen facilitates children's experience with a tangible programming language: mTiny moves on engaging thematic maps thanks to programs created through physical blocks. In this way, children get immediate feedback on their work, facilitating error correction and developing problem solving skills, while encouraging initiative and creativity through multidisciplinary engagement on math, music, art and more through themed mats.

Cody Rocky

The MakeBlock Codey Rocky is a coding robot for STEAM education. Codey provides an entertaining learning experience and introduction to programming for ages 6+. With the combination of easy-to-use robotics hardware together with mBlock 5 block-based programming, you'll be up and coding within minutes.

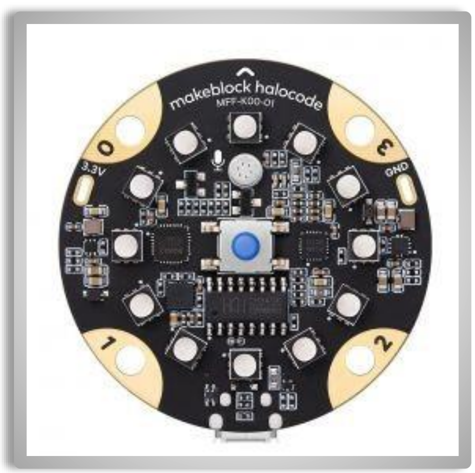
Codey Rocky features an innovative 2 in 1 design structure:

Brainy Codey. Codey is the brains of the outfit, having over 10 programmable electronic modules that produce enough data for a host of applications.

Agile Rocky. Getting around is what Rocky loves best. Not only will Rocky swirl and follow lines, it will also navigate around obstacles, and you will have programmed Codey Rocky to do it.

The robot has a host of electronic modules, including a sound sensor, light sensor and an LED dot matrix display. Students will be able to code Codey Rocky to play music, follow lights, mimic facial expressions and a whole lot more. With some easy coding you'll be able to turn imagination into reality and enhance your skills, ability and confidence while you're doing it.

Halocode



Halocode is a single-board computer designed for the educational world. Thanks to the intuitive software included learning to program is fun and immediate. Halocode offers a rich and diverse IoT and coding experience, making it easier for everyone to get excited about electronics. Halocode is an entry level product for electronic creations. Through a series of interesting and fun applications, Halocode combines the world of virtual programming with the physical world, helping to progressively master logical-computational thinking and exercise creativity. It can be used as early as 9/10 year olds because it is block programmable.

Integrating Mathematics teaching and learning in the whole educational process

Taking into account the difficulties, if not failure, of traditional Math's teaching, Mind Maths proposes to use ER to integrate Math's in all the disciplines, and in the education of hard and soft skills.

Effective Math education has to center on interest and experience in early childhood, building new knowledge on the basis of what young children already know and advancing rich and exciting scientific experiences

It is also worth stressing that in recent years, an A (Art) has also been added, spelling STEAM, widely defended as a multi- and trans-disciplinary approach aiming at the solution of socially relevant problems through innovation and creativity. The goal of this approach is to prepare students to solve the world's pressing issues through innovation, creativity, critical thinking, effective communication,

collaboration, and ultimately new knowledge. Mathematics and iconographic art (as well as in music) are two close fields, as evident in the artistic culture of millennia. Combining the two, or three, disciplines will enrich an integrated and competitive education.

In a way, the integrative Math's education is more pertinent and viable for elementary school, because teachers teach most of the subjects to the same class. So, interdisciplinary and multidisciplinary treatments would not be a drastic change in elementary school and early-years education. In goal-directed preschool, an integrated Maths approach fits in well with the didactics of early childhood education that is at present applied in the classroom. Teachers need to be carriers of both knowledge of the content and updated skills on how to generate situations that support the learning of their students.

Modules' actualization modalities

The educational robotics modules to support elementary school mathematics developed here are set for a two-hour session. In fact, unlike other Modules in the project, the educational robotics sessions dedicated to undergraduates in primary education need more time, because building the robots themselves, as well as programming them, or building the unplugged programming tools - which are an integral part of the educational process - takes time.

The Smart City

To place the modules in as real an environment as possible, we imagined inventing a smart city where robots move autonomously, and the city is sustainable. In this way, concepts of number, space, measurement, time, and so on become real for children. Here we present some scenarios, describing them from the point of view of programming and the benefits for math learning.