Flipped Learning Practices to Release Maths Anxiety with the Use of Robotics 2020-1-TR01-KA203-092209

Basic Principles of Designing and Implementing Maths Education in Primary Schools through the Use of Robotics and Blended Learning Approach

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

Erasmus+

Scuola di Robotica
UNIVERSITY OF LATVIA
Politécnico de Viseu
EduCloud IDEAS FIRST

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

TABLE OF CONTENTS

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

INTRODUCTION TO THE PROJECT

Mathematics education is considered to be the master key 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.

As indicated in the research (Pro Bono Economics) people with poor numeracy skills are more than twice as likely to be unemployed. According to the research (OECD), pupils beginning secondary school with very low numeracy skills have an exclusion rate twice that of pupils starting secondary school with good numeracy skills. Around 90% of new graduate jobs require a high level of digital skills and digital skills are built on numeracy. Therefore, it is incumbent on teachers to explore how these children's emotions and anxieties affect their achievement with mathematics, find effective solutions to facilitate their learning and reflect this into classroom environments.

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.

Aims and objectives

The main goal of this project is to enhance expertise of undergraduate students who are enrolled in primary teacher education programs. The project aims to help undergraduate students, pre-service primary school 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 approach including step-by-step hands-on learning practices and the use of online learning materials
- A video library including scenario-based learning/teaching activities for the use of robotics in mathematics education in primary schools

Specifically, the project aims to reach the following objectives:

- To raise pre-service primary school teachers' awareness of mathematics anxiety
- To contribute to eliminating the challenges which pre-service teachers will face while teaching children with mathematics anxiety
- To meet pre-service 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 pre-service teachers related to the teaching activities to engage children with mathematics anxiety in the learning process more effectively

When the objectives are reviewed, it is seen that the project has a keen interest in almost all aspects of pre-service teacher education, including improving teacher knowledge and expertise in dealing with primary students experiencing math anxiety. It is within the scope of this work to equip pre-service teachers with the necessary skills and experiences to help primary students with math anxiety. At the same time, it is aimed at increase pre-service teachers' awareness toward math anxiety. It should be a core skill for pre-service teachers to understand primary students' emotional as well as cognitive level in mathematics.

Expected impacts of the project

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Impact on undergraduate students;

The project activities will directly impact on the acquisition of professional skills which make undergraduate students enable to respond to academic, social and emotional needs of children with MA. These children are under the threat of being excluded by their peers, being labeled as lazy and developing avoiding and introverted behaviors in time. This project will give a chance to undergraduate students who will work with these children, to apply effective teaching activities to meet their needs. The workshops and seminars will increase undergraduate students' occupational affection. In this way, the challenges which are possible to be encountered in teaching environments and the ways of how to minimize them will be learnt. The project will raise awareness of classroom management strategies to involve all students in learning activities in a safe and positive environment. This will lead undergraduate students to practice innovative and interactive classroom management strategies and they will display desired approaches, attitudes and behaviors (especially during internship practices) so the project will indirectly have contributed to the constitution of supportive and encouraging learning/teaching environments in primary schools. The developed training materials will be published on the project website and the eTwinning platform so access to training materials will always be open to the public. Project partners will go on to give training courses after the project because many undergraduates are expected to improve their knowledge and skills through these training.

Process-oriented results

1- The practical implementation of the project outputs will contribute to the strengthening of a sustainable European Area of Higher Education in the mathematics education field, MA in particular.

2- It will contribute to the flow of information in and out of Europe by attracting teaching professionals to use the modular curriculum designed with flipped learning proposed by this project to overcome challenges that they face and implement successful classroom management.

3- The project will support cooperation, mutual interaction, including cultural integration, capacity building and know-how exchange between institutions working on the primary school teaching in a perspective of mutual interest. Furthermore, a standard research sample will be developed and implemented during the project practice.

This project is foreseen to make an impact on;

a. Primary school pre-service students in terms of enhancing their teaching skills and developing the quality of teaching in primary school classroom environments

b. Children with MA in terms of early intervention and active participation in the teaching processes through innovative teaching approaches

c. Academia in terms of providing a comprehensive study example and inspiring new research in the area

All interested people in Europe and all around the world will benefit from the project results since these training activities will continue and all the intellectual outputs will be open access.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

1. MATHEMATICS EDUCATION IN PRIMARY SCHOOLS

1.1. General objectives of mathematics education in primary schools

In Turkey, the general objectives of mathematics education at primary level are as follows (Ministry of National Education [MoNE], 2018);

1. Students will be able to develop their mathematical literacy skills and use them effectively.
2. Students will be able to understand and use mathematical concepts in daily life.
3. Students will be able to easily express their own thoughts and reasoning in the process of problem solving, and see the deficiencies or gaps in the mathematical reasoning of others.
4. Students will be able to use mathematical terminology and language correctly to explain and share their mathematical thoughts in a logical way.
5. Students will be able to make sense of the relationships between people and objects, and the relationship among objects while using the meaning and language of mathematics.
6. Students will be able to develop their metacognitive knowledge and skills, and consciously manage their own learning processes.
7. Students will be able to use their estimation and mental processing skills effectively.
8. Students will be able to express math concepts with different representation styles.
9. Students will be able to develop a self-confident approach to mathematical problems by forming a positive attitude towards mathematics with their experience in learning mathematics.
10. Students will be able to develop the characteristics of being systematic, careful, patient and responsible.
11. Students will be able to develop their research, knowledge generation and use of skills.
12. Students will be able to realize the relationship of mathematics with art and aesthetics.
13. Students will be able to appreciate knowing mathematics which is a common value of humanity.

In Italy, the Italian Ministry of Education released the National Digital School Plan (PNSD), a project designed to guide schools along a path of innovation and digitalization, as provided for in Law 107/2015, a program became strategic so that something finally changes in certain realities of Italian schools. The PNSD outline the need to innovate the teaching mathematics, such as:

"It is essential to strengthen the introduction of the problem posing and solving methodology in mathematics teaching, as well as to promote the use of advanced calculation environments in the teaching of mathematics and technical-scientific disciplines, and to introduce elements of educational robotics into secondary school curricula".

In Latvia, the Ministry of Education and Science has implemented the education curriculum reform. The improved content and approach in general education has to been implemented in steps, starting from 1 September 2019 in preschool,

Grades 1, 4, 7 and 10 of 1 September 2020,

Grades 2, 5, 8 and 11 of 1 September 2021,

Grades 3, 6, 9 and 12 of 1 September 2022.

At the end of 2016, 100 pilot schools in Latvia were selected for improved training content and approaches. Result of improved content and approach is knowledgeable teachers with the skills needed to manage the learning process, motivated and actively educated pupils who will be prepared for future challenges and competitive internationally, confident and peaceful parents and child-empowered representatives (Skola, 2019).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

The aim of mathematics teaching/learning in primary school is to promote the harmonious development of each pupil's personality, involving intellectual, volition and emotional aspects, and, by stimulation of the pupil mathematics' culture development, which includes a system of skills, knowledge and attitudes, to foster the implementation of the main mathematical comprehension principles into the practical life-activities. The predetermined mathematics teaching/learning aim defines the changes in the mathematics acquisition in primary school – it is necessary to alter the direction from the ascertaining of facts, regularities onto the formation of new, intellectual structures. It is possible to implement it, only if the appropriate education contents, appropriate teaching/learning methods and work forms are discovered. Thus, for mastering of mathematics in primary school, the pupils should be provided with the opportunity to learn such skills and knowledge, attitudes, which are better for the recognition of the mathematical concepts existing in the environmental issues, to implement the mathematical skills and knowledge into the daily life situations encountered by the pupils when solving definite practical problems (Table 1).

Table 1. Aim of Mathematics Education in Latvia

Aim of Mathematics Education in Latvia	
Develop students' awareness of mathematical methods and develop skills to use them in understanding of surrounding world pasaules izzināšanā, other school subjects and diverse activities (Matemātika, 2005).	The purpose of learning the math field for a pupil is mathematical literacy, which means using of math tools meaningfully, performing calculations, processing data, applying the characteristics of shapes, seeing relationships between measurements, decision in general and modeling, choosing an appropriate approach or method in problems, awareness of the need for proof and the formation of reasoned decisions in situations with mathematics content, other fields of learning and real context (Matemātika, 2019).

The objectives assigned to the math education highlight the priorities in the mathematics content, also the need to develop thinking skills in pupils by identifying and formulating legal relationships, reasoned judgments (Table 2).

Table 2. Objectives in Mathematics Education in Latvia

Objectives in Math Education in Latvia	
• skills to do calculation with three-digit numbers in the mind, by writing notes, with a calculator; • skills about basic shapes in geometry; • skills to solve practical content tasks by using measurement and arithmetic techniques related to daily lives, science, environment and health issues; • skills to obtain information from tables, column charts, reference sources; • the ability to use mathematical terms/keywords; • the ability to participate in simple mathematical projects, to listen to other opinions and to express one's own (Matemātika, 2005).	• use the math language by reading and writing accepted symbols, explaining their importance when designing mathematical text; • developing thinking skills by identifying and formulating relationships between measurements, numbers and shapes, developing experience of making mathematically improved decisions and applying problem solving strategies; • to make operations with real numbers by modeling in practice and geometrically, using the ten base system of numbers and the characteristics of the operations, selecting the appropriate techniques, strategies; • make algebraic modifications by explaining the meaning and modification of expressions by modeling them geometrically; • solve tasks with practical or other school subject fields, by establishing and resolving a mathematical model of the situation, assessing the relevance of the mathematical solution to the context; • developing skills work on data by formulating an experience-related subject, planning data acquisition, practical acquisition, sorting and analysis; • Describe and use the characteristics of shapes and 3D shapes by discovering and formulating them, developing space concepts (Matemātika, 2019).

In Portugal, basic education is referred to the period between the 1st and the 9th year of school. The first segment of this cycle of studies, the 1st cycle of basic education (1st CEB), is the cycle that follows pre-school education, and includes the first 4 school years, for students between 5 and 10 years, in general.

The curriculum structure of the 1st CEB covers different components in addition to Mathematics: Portuguese, Study of the Environment, Art Education (Visual Arts, Dramatic Expression / Theater, Dance, Music), Citizenship and Development, Physical Education and English.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Between public education (managed by the Portuguese government) and private education, 393,793 students were involved in the 1st CEB in 2019, distributed by 4140 schools and supported by 30,178 teachers in this level of education.

The curricular guidelines for teaching Mathematics in basic education are presented in two documents: *Programa e Metas Curriculares* (presented in 2013) where are registered the knowledge, skills and attitudes to be developed by students and *Aprendizagens Essenciais* (presented in 2018) which describe a common set of knowledge to be acquired, as well as the skills and attitudes that must be developed by all students, in each subject area.

The curricular guidelines are supported by 2 main purposes for teaching, throughout basic education: i) Promote the acquisition and development of knowledge and experience in Mathematics and the ability to apply it in mathematical and non-mathematical contexts; ii) Develop positive attitudes towards mathematics and the ability to recognize and value the cultural and social role of this science. Therefore, the indications arise in the sense that students, throughout basic education, understand concepts, techniques, procedures, properties and mathematical relationships and develop the ability to mobilize them to solve and formulate problems in different contexts. In addition, the curricular guidelines highlight the importance of developing students' skills of abstraction and generalization and of developing logical reasoning as well as other forms of mathematical argumentation. The mathematical communication is also a transversal capacity that the Portuguese guidelines highlight as fundamental to develop in students, creating opportunities for them to be able to describe, explain and justify, orally and in writing, their ideas and reasoning. At the same time, students are expected to feel an interest in mathematics, recognize their role in the world and in the development of other sciences, technology and other fields of human activity, and also develop the ability to appreciate aesthetic aspects of Mathematics, recognizing and valuing the area of Mathematics as an element of humanity's cultural heritage.

1.2. Teaching methods & techniques used

In Turkey, the methods and techniques that are recommended to be used and therefore researched while teaching primary school mathematics are as follows;

Creative drama (Aktepe & Bulut, 2015), Teaching through sets of activities (Kazez & Genç, 2016), Teaching through games (Boz, 2018), Cooperative teaching techniques (Serin, &Korkmaz, 2018), Mind games (Şahin, 2019), Problem solving and posing (Cankoy & Darbaz, 2010; Serin, &Korkmaz, 2018).

In addition to these methods and techniques, while teaching mathematics, emphasis is placed on the using of music, making use of modeling, and achieving the abstraction of mathematics through concretization.

In Italy, researchers have collected some innovative practices applied by teachers for the teaching of mathematics able to release math anxiety. These innovative activities include:

- The use of the interactive whiteboard
- The use of coding with free software (Scratch, Open Roberta for middle school)
- The use of educational robotics
- Using games

Teacher Giuliana Finco (Comprehensive Institute C. Selvazzano 1 of Padua, Italy):

“In Against the Math Hour, Lockhart states that the student only learns when he has to solve a problem which is interesting, involving and challenging for him, so that he has to develop his own solution and then a demonstration. I have made this approach to the teaching of mathematics my own, trying to translate it into my teaching practice, also by participating in initiatives and experiences aimed at active and experiential learning: for example, by inventing problems as online challenges of the beautiful blog What is your problem? by Paola Limone and Maurizio Zambarda, in which I participated with my 2.0 class. Or by building geometry cities: from Solidopoli, the city of solids, to Pianopoli, the city of plane figures.”

Serafino Caloi (he teaches mathematics in the elementary School of Tregnago, Verona):

Richard Skemp distinguishes instrumental mathematics from relational mathematics.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Instrumental mathematics is based on formulas, remembering, exercises, and products.

Relational mathematics is based on reasoning, thinking, problems, processes it adapts better to new tasks, is easier to remember, and is more effective.

In my work I have always sought strategies and paths to cultivate not only mathematical competence but also the pleasure of doing it, in every child, not one less, none exclude. Not one less is the name of a project that I am carrying out thanks to the Amiotti Foundation and with which I will try to reach all children with what I call the best school. It is possible to make Maths fascinating and pleasant, building real competences (not only in school but also outside the classroom) and, above all, that can develop everyone's potential. I now find that the possibilities that technology offers us in supporting classroom action aimed at proposing a certain way of doing mathematics are remarkable."

Giosuè Verde (he teaches math in a very marginalized district of Naples at the Scuola primaria 10H, Scampia, Naples): Unfortunately, the two mathematics - that of the syllabus and the fascinating and funny one - have to march hand in hand. When you find yourself in a much degraded socio-cultural context, such as my own in Scampia, where pupils enter fifth classes without knowing the multiplication tables, then everything becomes more difficult. I try to present a lot of my teaching work in the form of games, to ensure that the pupils are passionate about mathematics and do not experience it as something abstract and difficult. I bring every experience that happens in the classroom and at home to the scientific or mathematical level and I try to get my pupils used to asking questions, not taking anything for granted. I don't give them problems to solve at home: they have to invent them! Only if they know how to invent them will they be able to solve them. I try to put them in difficulty with my hundred thousand whys, so that they understand that everything has a reason, everything has an origin, a cause, an influence: chance does not exist. Perhaps.

Mathematics has to be experienced, experimented and emulated, and this happens above all in games. If I have a virtual supermarket built in my school to take my pupils there and play at being grown up and buying, selling, discounting, making loans and installments. I have to do it without worrying about notebooks and written assignments. These are fundamental experiences that give pupils the ability to transfer their mathematical knowledge to everyday reality: and it is there and only then that it can be transformed into abstraction, not before! Otherwise, it is a mechanical mathematics, not metabolized. And in fact, when the pupils then have to solve problematic situations, they find themselves in great difficulty: they may be able to add and divide very well, but they do not know when to apply them, they do not have the logical paths to identify a meaningful and conscious use.

In Latvia, the emphasis on the learning approach in education:

- transition from pupils' passive learning and memorizing factological material to an active knowledge process under the leadership, self-expression and creativity of a teacher;
- linking knowledge and skills to real life;
- a cross - disciplinary approach that eliminates content fragmentation and promotes teacher cooperation in the organization of the learning process;
- providing an opportunity for a pupil to learn deeply, understand the relationships and develop the ability to transfer knowledge to new, unknown situations (Matemātika, 2005)

Pupils use math tools meaningfully in context of mathematics, in context of other school subject fields, in real context:

- making calculations,
- processing data,
- using of the characteristics of shapes
- find out connections, relations between measurements,
- making decisions in general and modelling math,
- choose appropriate approaches or strategies in problem based situations,
- aware of the need for proof and forming reasonable decisions (MK noteikumi Nr. 747, 2018; Skola2030, 2019).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Table 3. Steps and Strategies in Math Education in Latvia (Matemātika, 2005).

Steps of Math Acquisition in Latvia	List of Strategies for Math Acquisition in Latvia
• formulating the problem; • clarification of the teacher; • discussion (acquiring new skills and concepts); • appropriate practical work of pupils in learning a theoretical course; • strengthening basic mathematical skills and training (by learning new learning methods, it is important not to lose the traditional calculation skills and skills in algebra for solving of problems successfully); • practical content tasks; • research work. Research skills are an important part of the use of mathematics, which creates more positive ideas about mathematics and enables you to learn more successfully (Matemātika, 2005).	• Brainstorming • Problem solving • Conversation, talk • Analysis of situation, case • Game, play • Narration, narrative • Solving of task • Visualization • Analysis of text • ICT • Demonstration • Discussion • Essay • Questions • Role play • Research paper (Matemātika, 2005).

In each math lesson:

- formulating clear objectives or the results to be achieved;
- the selection of meaningful tasks and supporting materials;
- providing an evolving feedback and promoting thinking about pupils' learning process;
- the development of values, attitudes, general (transversal) skills, which will help the pupil to exploit what he/she has learned in the future, bearing in mind the variability of knowledge;
- implementation of socio-emotional dimension;
- applied formatting assessment or assessment to improve performance in the learning process (Matemātika, 2019).

Special attention in math teaching is devoted to learning mathematical skills. **The mathematical skill as purposeful and successful solving of mathematical expressions by rational means.** Successful solving of the mathematical problems and exercises fosters and maintains the possibility to implement the mathematical skills into the miscellaneous innovative real life activity situations. The mathematical skill fits into the group of cognitive skills as special skills. Learning mathematics the pupil obtains the mathematical skills by consecutive passing from the previous skill's level to the next – a higher skill's level. To make the access to every mathematical skill's level successful, as well as the acquired mathematical skills stable, lifelong, it is necessary to use for learning the conditions which maintain the realization of every mathematical skill's level (see Figure 1):

- the first level mathematical skills – a manipulation action with objects,
- the second level mathematical skills – a purposeful system of exercising,
- the third level mathematical skills – the stage of implementation into the life-activity situations.

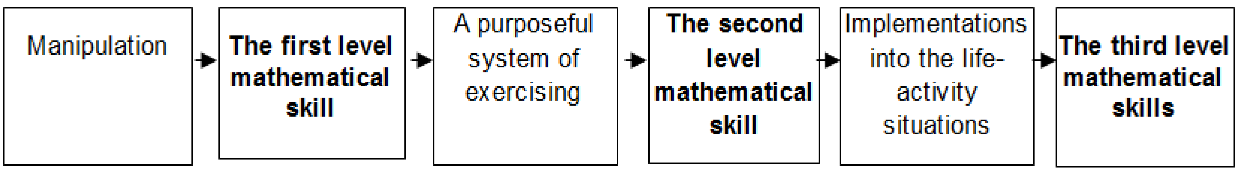


Figure 1. Acquiring of mathematical skills' stages in primary school

As a result of the mathematical skills' achievement use, the pupils consecutively reach the next skill's level. The acquired mathematical skill level quality can be established according to the

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

following criteria: result quality, easiness of the automation stage level, necessity for assistance, use based on the sample, in analogue or dissimilar situations (Helmane, 2006).

Primary school pupil's mathematics education content consists of the skills to be fostered, the knowledge to be acquired and the culture and social experience to be inherited during the teaching/learning activities. While learning mathematics contents, one learns also the intellectual values, gains conviction and attitude formation experience, experience of emotional culture and personality development experience by observing the mathematics education aim and primary school pupils' learning regularities. For the formation of the mathematics education contents of primary school, it is necessary to sustain the following pedagogic conditions: concentric layout of mathematics education contents, life-activity principle, and the thematic approach as integrated subject component and peculiarities of pupils' development (Helmane, 2006) (Figure 2).

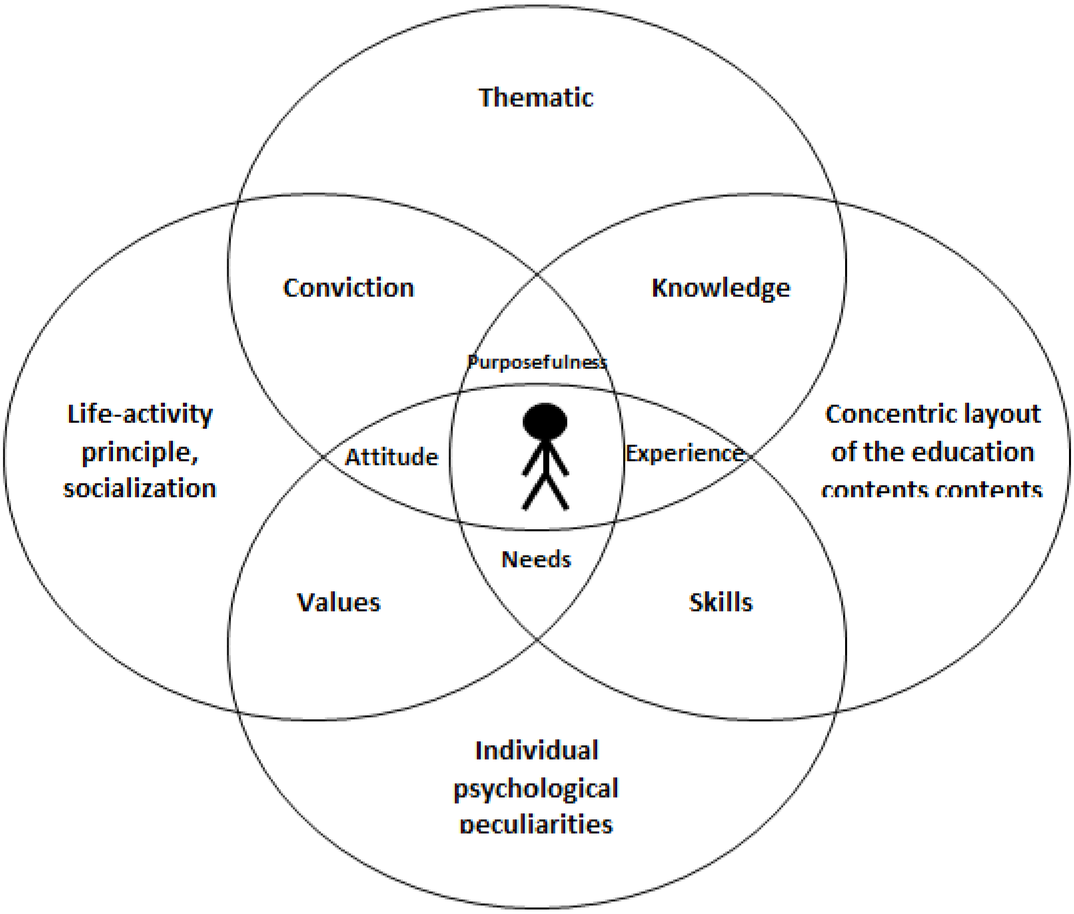


Figure 2. Conditions of mathematics contents development in primary school (Helmane, 2006).

The layout of the education contents in the **concentric circles** or gradual arrangement of the mathematics contents finds itself in all stages, with every next stage the mathematics contents expands and involves the contents of all the previous stages. Observing of **individual psychological peculiarities** in the mathematics subject contents foresees the maintenance of the pupils' intentional practical activities by the miscellaneous visual aids, while structuring and dividing contents maintain the transition from the simple to more complicated, based on the pupils' experience. In its turn, by observing **the principle of life-activity** mathematics brings the pupils nearer to the surrounding life and nature, thus, forming the relations with the adult life, human work, nature issues and phenomena, where the routine theoretical and practical problems are perceived by the pupils after finding more adequate means and ways of problem solving, so being more successfully trained for the life-activities. And the **thematic approach** implements the main tendencies and cognitions of the integrated subject teaching/learning, involving the integration of various contents areas, investigating the entirety of the world, which is brought closer to different subject contents, as a consequence, the pupils are bestowed with the link to the contents of different subjects and the link to life-activity (Helmane, 2006).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

The current Portuguese basic education mathematics program offers teachers and educational institutions the freedom to decide which methodologies and resources are best suited to each school context, and therefore does not impose specific methodologies for teaching mathematics.

Based on the results of research in education (national and international) and the orientations of previous programs (such as, in particular, that of 2009), the general methodological orientations for the teaching of Mathematics in Portugal have suggested an exploratory model for the teaching and learning of Mathematics.

The diversity of tasks for work in class, either in terms of their nature (more closed or more open, of lower or higher challenge), or in terms of the context on which they are based, the connections that allow to establish, within or outside of mathematics itself and the resources they suggest (teaching materials, applets or dynamic geometry environments) is a recommendation with a high profile in the exploratory model. It is also referred the work in the classroom as diversified, with moments for individual work, in small groups and in a large group (usually in the discussion and systematization of ideas resulting from the students' work). The idea of using different representations for the same concept and mobilizing different representations in solving tasks is an idea with high potential for learning meaningful mathematics. Also the more systematic and contextualized integration of the History of Mathematics in the classroom has been an important aspect, although in practice, it still seems to come up with low evidence.

1.3. Content of the mathematics education in primary schools (which subjects in general? addition, multiplication, subtraction, etc.)

The Turkish primary school mathematics curriculum consists of four learning domains: Numbers and Operations, Geometry, Measurement and Data Processing. While all learning domains are included at each grade level, some sub-learning domains come into play after a certain grade level (MoNE, 2018).

Numbers and Operations

In the natural numbers sub-learning domain, learning outcomes start with the teaching of numbers. As the grade level increases, it is aimed to learn larger numbers and operations.

Geometry

Geometry learning outcomes are included in all grade levels. It was thought that it would be appropriate to consider the basic concepts sub-learning domain in geometry after the 3rd grade, considering the readiness of the students.

Measurement

Measurement starts with determining the feature to be measured, comparing and ranking. Then it continues with measuring using non-standard units first and then using standard units. Finally, applying and interpreting this information reflects the progress of the measurement learning field. In these studies, it was aimed to make an intuitive comparison and ranking first. Afterwards, it was aimed to make measurements using non-standard and standard units.

Data Processing

Data Processing learning domain is addressed from the 1st grade in a way to support the Numbers and Operations learning domain. While shaping this learning domain, the points highlighted in international exams at primary school level were also taken into consideration.

After learning the numbers in the first grade, the concept of digit is taught. Part, part-whole relationship is presented. Teaching goes on with numbers less than 20. Rhythmic counting is done up to 100. Addition and subtraction operations start from the first grade. Basic features of addition and subtraction are given. Transactions are made mentally with strategies. All and half fractions are taught. In the first year, students are expected to name the shapes according to the number of corners and edges. It is aimed to classify geometric objects with examples from daily life. It should be ensured that the expressions giving directions and directions are associated with daily life situations. They must be able to determine the relationship in a pattern whose elements are objects, geometric shapes, and bodies. It is mostly aimed to create a three-element geometric pattern. In the first class, there is an order of objects according to their lengths. It is aimed to use the calendar and realize that

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

a week is 7 days. Full and half hours are being read. Reading tables belonging to two data groups at most is included.

In the second grade, the main goal of the numbers and operations learning area is to teach the concept of digits. Numbers less than 100 are divided into place values using models. Multiplication and division operations are started in the second grade. The relationship of whole and half with quarter is taught. The second grade includes a circle. Students are expected to recognize and model geometric objects. The use of mathematical language to describe position, direction, and movement is taught. It is aimed to find symmetrical shapes. They should identify items that are missing in a repetitive pattern. In the second grade, measuring with non-standard units is taught. It is aimed to recognize standard measurement units and measure lengths in centimeters and meters using standard tools. It is aimed to solve length problems involving addition and subtraction by using models. The relationship between “lira” and “piaster” is explained. In the second grade, it is aimed to read the full, half, and quarter hours. Relationships between minute-hour, hour-day, day-week, day-week-month, month-season, season-year are expected to be explained. It is aimed to measure the masses in kilograms and to sort the given objects according to their masses. For a given research question, it was aimed to collect data, to represent and interpret the data with table and object graph, to prepare a frequency table and tree diagram, and to be able to read the figure graph.

In the third grade, three-digit numbers are modeled, read, and taught. Definitions of odd and even numbers are taught. Also, at this grade level, the number systems and numbers used by ancient civilizations are introduced. The process of mental multiplication and division is at this grade level. Fractional terms are introduced by emphasizing the part-whole relationship. Unit fraction concept is explained. In the third grade, the students are aimed to identify the faces, corners, and edges of objects. They are expected to draw triangles, squares, and rectangles using a ruler. They are made to realize that shapes such as squares and rectangles have more than one symmetry line. They are asked to draw the coating pattern they make on dotted or squared paper. It is aimed to solve the problems involving the relationship between “lira” and “piaster”. Parts of the day are expected to be said. In the third grade, it was aimed that students could read the time in minutes and hours. Recognizing where kilograms and grams are used and explaining the relationship between these units. It is introduced what the standard liquid measuring unit is. It is measured in liter and half liter. The third grade includes measuring the circumference of geometric shapes, calculating, and solving problems related to them. Estimating the area with non-standard measurement units is taught. It is expected to read, interpret, and edit simple tables with at most three data groups.

In the fourth grade; Reading and writing 4, 5 and 6-digit numbers, and dividing them into parts and specifying the digit values are taught. Long divisions are at this class level. Definitions of simple, compound, and integer fractions are taught. An introduction is made to addition and subtraction in fractions. Adding and subtracting denominators with equal fractions is explained and related problems are solved. In the fourth grade, they are asked to classify triangles according to their side lengths. Students are expected to create structures suitable for drawings created with isometric or squared paper and matching cubes. It is aimed to draw the symmetry of a given shape with respect to the line. It is aimed for fourth grade students to recognize the plane, give examples, determine the angles and diagonal that make up the angle, name it, and classify the angles. In the fourth grade, it is expected to know millimeter and its relation with other measurement units. In the fourth grade, hour-minute, minute-second, year-week, year-month-week-day relationships, and expressing one in terms of the other are discussed. The measurement of half and quarter kilograms in grams is included. It is taught to predict where tons and milligrams are used and to use them in problem solving. In the fourth grade, it is expected to explain the relationship between the perimeter of the square and rectangle, and their side lengths. It is aimed for them to examine and create the column chart.

In Italy, even if primary school tries to rebrand appreciated mathematics, it means that it does not sufficiently prepare students to deal with algebra, geometry at middle school level, competences that should be built up from an early age, with courses that stimulate productive, not just reproductive, thinking activities.

The most enlightened teachers (Amiotti, Giuliana Finco, Serafino Caloi, Lorenza Scarinzi, Giusué Verde, Tullia Uschitz, et al) with whom School of Robotics is in contact argue that students need to be accompanied to go beyond the mere competence, cultivating a taste for Math, and pleasure in doing. There are few school textbooks which show care for reflection, or the choice of

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

activities which encourage productive thinking, for example by building a learning environment which encourages discovery.

Mathematics is still often taught the way old teachers taught the current teachers. It is certainly not a popular subject. The humanistic culture is still very strong today in Italy and it has not yet been understood that mathematics is first and foremost concreteness, experience, logic, seriation and cataloguing, hypotheses, proof and verification ... In school, it is almost always just method, algorithm, calculation and measurement.

Certain ways of doing things, such as resorting to technical and not very reasoned work, are justified by the false belief that this is the best proposal for those with difficulties. On the other hand, focusing only on technical skills is more reassuring for the teacher because it seems – and these teachers stress seems - easier to work on something to be learned immediately and so, for example, to say “learn the multiplication tables by heart”, rather than working on building them together with the child, focusing on the pleasure of doing them.

We must go beyond competence, cultivating the taste and pleasure of doing. There are few school textbooks that show care for reflection, or the choice of activities that encourage productive thinking, for example by building a learning environment that encourages discovery. The use of technical counting skills in primary schools (e.g. games to learn multiplication tables) are considered by these innovative teachers to be poor techniques, because what should be done is to work with the children to 'build multiplication tables' together, to build numbers, working on building them together with the child, focusing on the pleasure of doing them.

The primary school teachers with whom Scuola di Robotica is in contact have tried to profoundly modify the methodology of teaching mathematics, drawing inspiration from various authors. Richard Skemp, Seymour Papert, and more recently, to Paul Lockart.

“Mathematics is the art of explanation. If you deny students the opportunity to engage in this activity—to pose their own problems, to make their own conjectures and discoveries, to be wrong, to be creatively frustrated, to have an inspiration, and to cobble together their own explanations and proofs—you deny them mathematics itself.”

Mathematics content is associated with the development of skills in practical activities the so called ‘hands on’ as well as the inter-correlation of the acquired knowledge based on the concept; also, skills that can be applied in lifetime actions as well as the development of a personal significant attitude, values and goals (Figure 3).

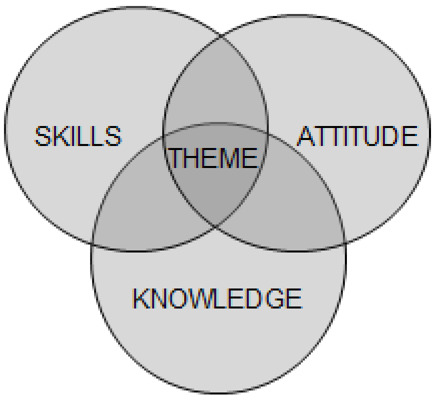


Figure 3. Mathematics content (Helmane, 2011)

The mathematics curricula of Grades 1 to 6 of basic education include three content blocks:

- composition of mathematical sets;
- application of mathematics in the analysis of the processes of nature and society;
- structuring mathematical models and investigation with the help of methods typical of mathematics (Table 4) (Matemātika, 2005).

Whereas the mathematics learning programs of Grades 7 to 9 of basic education and in Grades 10 to 12 of general secondary education include three content blocks:

- mathematical models;

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

- research activities;
- the aspects of mathematics of the interaction of man, the society and the environment (Matemātika, 2005).

Table 4. Math Content Blocs (Matemātika, 2005)

Composition of mathematical sets	Application of mathematics in the analysis of the processes of nature and society	Structuring mathematical models and investigation with the help of methods typical of mathematics
Numbers and calculation	Measurements	Language in Math
Shapes	Information, data, analysis	Designing of models

The new teaching/learning content in mathematics is organized according to the most essential key concepts of the content or the big ideas that the pupil has to acquire in order to develop common understanding about the surrounding world and oneself in it. The big ideas form the structural framework of the compulsory teaching/learning content; requirements for the acquisition of the teaching/learning content or the learning outcomes that the pupil has to attain finishing the particular stage of education are described according to these big ideas. These learning or expected outcomes are defined both for each theme in the teaching/learning content and the respective educational three-year stage, finishing Grade 3, 6 and 9. The learning outcomes at the end of the respective educational stage define also the learning outcomes in connection with the acquisition of transversal skills, including also the civic participation which directly refers to citizenship education. This is a new formation in the mathematics curriculum which has been developed as a result of the education content reform. Besides, the basic course mathematics curriculum of the secondary school was used in the analysis of the mathematics content for Grades 10 – 12 where the content is no longer divided per particular grades but the general common content for all secondary school grades is given together. This allows schools to organize themselves the acquisition of the content in the particular sequencing during this period. This is the novelty after the introduction of the education content reform. This also defines the transversal skills, such as critical thinking and problem solving, innovation and entrepreneurship, self-guided learning, cooperation, civic participation and digital literacy (Skola2030, 2019). This study analyzes the learning outcomes in the new mathematics curriculum according to the selected criteria at the end of the education content stages (finishing Grades 3, 6, 9 and 12) (Table 5).

Table 5. Big Ideas in Mathematics Education (Matemātika, 2019).

Big Ideas in Mathematics Education	
Math Language	Math language is used for communication and scientific description of concepts, ideas, problems
Problem solving	Solve the problem in math - to see structures, systems, relationships, to create generalizations and to prove them
Numbers	Numbers are used to resolve specific, including practical tasks. There is a certain meaning for each action with numbers and there are certain laws/algorithms for executing them.
Measurements	The relationships between the values are described by algebraic models and functions. When using these models to solve problems, they are transformed by ensuring equivalence
Data	Data on objects, situations, events, processes can be mathematically processed, analyzed for reasoned decisions
Shapes	Exploring the characteristics, location, size of the shapes allows to address specific, including practical, problems, formulating general conclusions on objects, space, form

In Portugal, the Mathematics curriculum in the 1st cycle of basic education is structured according to 4 domains: Numbers and Operations, Geometry and Measurement, Organization and Data Processing and Transversal skills (Problem solving, Mathematical reasoning and Mathematical communication).

Numbers and Operations

In Numbers and Operations, one of the main objectives is to provide opportunities for the development of the sense of number, arithmetic operations and fluency of mental and written calculation (delaying the introduction of algorithms). In this cycle, they study the decimal numbering system and the set of natural numbers, later extending the study to the set of non-negative rational numbers, first in decimal representation and later, in the representation in the form of a fraction.

In the 1st year of the 1st cycle of basic education, students begin to understand the decimal numbering system, the meanings of the number and add and subtract numbers using the horizontal representation, using various strategies that show numerical relations and properties of the two

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

arithmetic operations. In the following year, they compare and order numbers, making estimates for sums, differences and products, using, or not, concrete material. It is in this year that unit fractions should be recognized as representations of a part of a whole divided into equal parts. In the 3rd year, they use multiplication and division to solve problems and calculate with non-negative rational numbers, in decimal representation, using the respective algorithms and mental calculation. In addition, they represent non-negative rational numbers in the form of a fraction and in the decimal representation, establishing relationships between the representations for the numbers, mobilizing them in solving problems in mathematical and non-mathematical contexts. In the last year of the 1st cycle of basic education, students expand their knowledge of the set of natural numbers with reading and representation in the decimal numbering system up to a million, compare and order natural numbers, operate them through the 4 operations and make estimates, assessing their reasonableness. Regarding the set of non-negative rational numbers, students work on calculations in decimal representation, using mental calculations and algorithms and represent numbers in fraction, decimal and percentage forms in problem solving.

Geometry and Measurement

In Geometry and Measurement, students' learning should be centered on the development of their ability to visualize and understand the properties of geometric figures, the notion of greatness and the measurement process. Students also identify, interpret and describe relationships in space, and describe, build and represent figures in two or three dimensions, characterizing their properties and establishing geometric relationships. In these 4 years, the quantities of money, length, area, mass, capacity, volume and time are introduced and different measurement processes are explored. The notion of angle is also introduced intuitively and the identification of right, acute, obtuse and shallow angles in polygons is suggested.

In the first two years of schooling, students identify and describe spatial relationships, placing themselves in space in relation to others and objects and identifying, comparing and describing properties of figures in the plane and in space, composing and decomposing them and recognizing similarities and differences. In these first years, the measurement work starts with the dimensions length, area, money, capacity, mass and time, suggesting the work with unconventional measurement units as well as the comparison and ordering of objects according to different magnitudes. In the 3rd and 4th years, students describe the position of objects in references using coordinates, justify classifications based on the characterization of properties of geometric figures in the plane and in space and measure quantities using now units of measurement of the international system. Students also identify angles (straight, sharp, obtuse and shallow) in polygons.

Organization and Treatment of Data

In terms of Organization and Data Processing, it is expected that students understand the statistical information represented in different ways, hoping that they will be able to read and interpret data organized in tables, graphs and diagrams.

Transversal skills

Problem solving is one of the transversal skills to work in the classroom, providing opportunities for students to learn how to solve problems, analyzing and comparing different strategies and reflecting on the results obtained. The situations explored in the classroom should also allow students to develop the ability to reason mathematically, formulating and testing conjectures and analyzing the reasoning of others. The development of the ability to communicate in Mathematics, orally and in writing, is another of the central intentions of mathematics programs in Portugal, where students are able to use the mathematical language appropriate to each of the mathematical contents.

1.4. General status of achievement levels in mathematics in terms of cognitive and affective processes (If you have statistics, please insert in the charts, otherwise delete them.)

The situation **in Turkey**: The rapid developments in the globalizing world make countries to develop and modify their educational goals according to their needs. Examining the outputs in the education systems of different countries and comparing them with our own system will also shed light on the development of our educational goals. For this reason, Trends in International Mathematics and Science Study (TIMSS) provides us with important comparative data at primary and secondary school levels. The 4th graders within the scope of this project took part in this exam in 2011 and 2015

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

in our country. A total of 6456 4th grade Turkish students from 260 schools participated in TIMSS 2015. In general, 49 countries at the 4th grade level took this exam (Yıldırım, Özgürlük, Parlak, Gönen, & Polat, 2016). Table 6 shows the average scores of 4th grade students from all education systems of TIMSS 2015.

Table 6. Average Mathematics Scores of 4th-grade Students, by Education System: 2015

Education system	Average score	s.e.	Education system	Average score	s.e.
TIMSS scale centerpoint	**500**	**0,0**	Australia	517	3,1
Singapore	618	3,8	Canada	511	2,3
Hong Kong-CHN	615	2,9	Italy	507	2,6
Korea, Rep. of	608	2,2	Spain	505	2,5
Chinese Taipei-CHN	597	1,9	Croatia	502	1,8
Japan	593	2,0	Slovak Republic	498	2,5
Northern Ireland-GBR	570	2,9	New Zealand	491	2,3
Russian Federation	564	3,4	France	488	2,9
Norway	549	2,5	**Turkey**	**483**	**3,1**
Ireland	547	2,1	Georgia	463	3,6
England-GBR	546	2,8	Chile	459	2,4
Belgium (Flemish)-BEL	546	2,1	United Arab Emirates	452	2,4
Kazakhstan	544	4,5	Bahrain	451	1,6
Portugal	541	2,2	Qatar	439	3,4
United States	**539**	**2,3**	Iran, Islamic Rep. of	431	3,2
Denmark	539	2,7	Oman	425	2,5
Lithuania	535	2,5	Indonesia	397	3,7
Finland	535	2,0	Jordan	388	3,1
Poland	535	2,1	Saudi Arabia	383	4,1
Netherlands	530	1,7	Morocco	377	3,4
Hungary	529	3,2	Kuwait	353	4,6
Czech Republic	528	2,2	**Benchmarking participants**		
Bulgaria	524	5,3	Florida-USA	546	4,7
Cyprus	523	2,7	Quebec-CAN	536	4,0
Germany	522	2,0	Ontario-CAN	512	2,3
Slovenia	520	1,9	Dubai-UAE	511	1,4
Sweden	519	2,8	Buenos Aires-ARG	432	2,9
Serbia	518	3,5	Abu Dhabi-UAE	419	4,7

As seen in Table, the TIMSS 2015 score average for all regions is 500. Turkey's 4th grade average mathematics score is 483. Based on this score, Turkish students' average math score is the 36th out of 49 countries. This result reveals that our country's 4th grade mathematics achievement is well below the TIMSS average.

The situation **in Italy**: The gap and the lack of good results in Math starts to increase after this school, in secondary schools of first and second degree (middle and high school in Italy), and this is documented in various ways, especially by the results of the tests in mathematics (OCSE-PISA) for which Italy is placed quite far from the excellences in Math. OECD-PISA tests show sufficient Italian results in problem-solving (510 compared to an OECD average of 500), but poor results in

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

mathematics (485 compared to an average of 494) and science (494 compared to an average of 501). There was, however, an average growth between 2002 and 2013 for the overall Italian performance.

This lackluster performance is not due to teaching in primary school but occurs immediately in the first year of secondary school (students are 14 years old), and it is also influenced by how the subject is perceived (and thus taught): it is a cold subject, difficult to understand, made up of formulas and algorithms to be memorized, not very creative, not very nice and not really easy. However, according to many European evaluators, Italian primary schools excel in many aspects, including STEM subjects.

The situation **in Latvia**: Since the 2013/2014 school year, combined diagnostic work for Grade 3 are taking place in teaching Latvian language, in mathematics. The purpose of grade 3 of the combined diagnostic work of the State is to evaluate the knowledge of the pupils and skills in teaching language and math in accordance with the Cabinet of Ministers on 6 August 2013 Regulation No 530.

The National Educational Content Centre has compiled the results of diagnostic work. The results were collected in both the teaching language part (Latvian and Russian) and mathematics (Valsts-Pārbaudes darbi, 2020) (Figure 4).

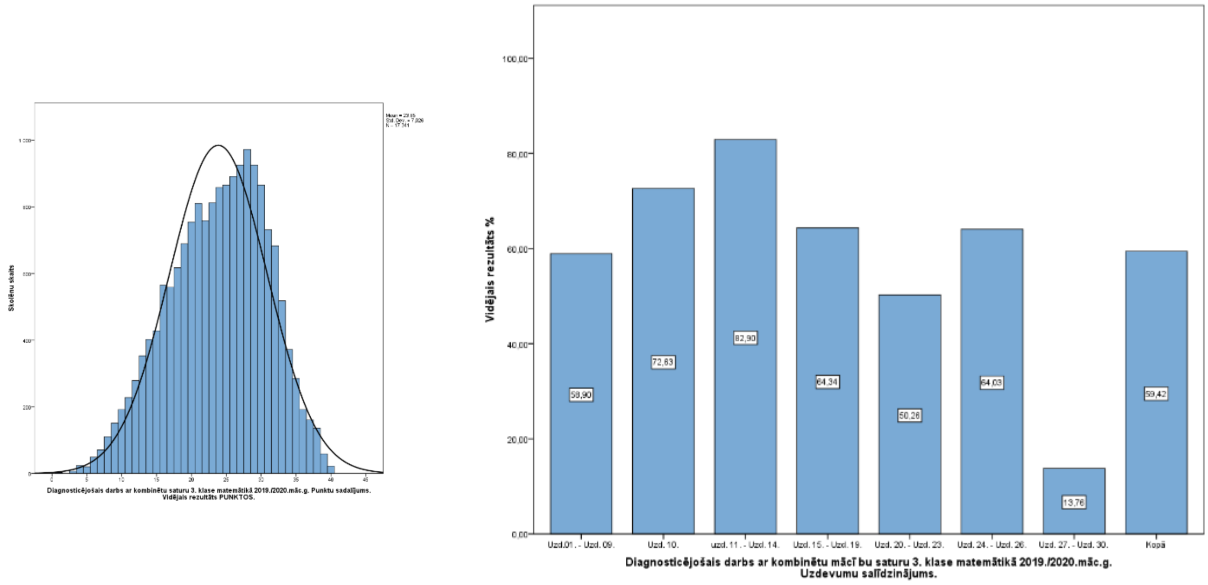


Figure 4. Results of Diagnostic work in Mathematics 3 grade 2019/2020 (Pārbaudes darbi, 2020).

1. Applies the math terminology
2. Applies the concept of the calendar to calculation in math
3. Used the concept of fractions for calculation in math
4. Uses the concept of clock time for calculation the tasks in math
5. Determines the size of the given fraction
6. Assess the given values, dissect the geometrical shapes
7. Knows which geometrical shapes can measure length
8. Solving a practical problem
9. Mathematically solve the problem
10. Uses a mathematical terminology/keywords, records/put the notes of calculation
11. Use the concept of a clock time, compare different times
12. Compare and find relationships between different times
13. Compare and find relationships between different times

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

14. Compare and find relationships between different times
15. Compares the values given in the chart and draws conclusions
16. Used chart for reading/finding information
17. Analyzes the given values in the chart and calculate sum
18. Uses mathematical terms/keyword *for how much* and records the transaction with numbers; calculates the subtraction
19. Uses mathematical terms/keyword *more times* and records the transaction with numbers; calculates the division
20. Knows what geometrical shapes are named quadrangles/ tetragons and finds them in a picture
21. Knows what geometrical shapes are named squares and finds them in a picture
22. Knows what geometrical shapes are named polygons and finds them in picture
23. Knows what geometrical shapes are named rectangles and finds them in a picture

24.-26. Uses mathematical keywords in writing an expression, calculates the value of an expression

27., 29. Analyze the given values and determine their number

28., 30. Explain your logical judgment

In Portugal, students of the 2nd, 5th and 8th years of schooling participate in the assessment tests that have as main objective to know the state of learning, identifying positive aspects and main difficulties. According to the Ministry of Education, these tests provide indicators for deciding what may have to be reinforced or revised, at school level, or in terms of educational policies. The last report of these tests was prepared in 2018 and was based on the following scale:

1. Students managed to respond according to expectations (C);
2. Students managed to respond according to expectations, but they can still improve (CM);
3. Students showed difficulty in the answer (RD);
4. Students failed to respond according to expectations (NC) or They did not respond (NR).

The performance results of 2nd year are shown in the following table (Gave / Ministério da Educação, 2018):

Mathematics Assessment Tests in Portugal, in 2018
2nd year of school | Students by performance category (%)

Domains (Blocks)	**C (%)**	**CM (%)**	**RD (%)**	**NC/NR (%)**
Numbers and Operations	12.2	19.9	39.5	28.4
Geometry and Measurement	27	28.4	32.1	12.5
Data organization and processing	61.2	5.3	22.4	11.2

The same report mentions student performance at levels of cognitive complexity classified as follows: Lower (Knowing), Medium (Applying), Higher (Reasoning) (Gave / Ministério da Educação, 2018):

Results by level of cognitive complexity in the Mathematics Assessment tests in Portugal, in 2018
2nd year of school | Average correction percentage

	Knowing	**Applying**	**Reasoning**
mathematics	68.7%	49.8%	41.3%

As can be seen, the percentage in relation to correct performances is high at levels of lower cognitive complexity, but it reduces considerably when analyzing items that mobilize more complex cognitive processes. At the international level, the performance of Portuguese students in Mathematics is well known.

According to the *Trends in International Mathematics and Science Study* (TIMSS), the performance of 4th grade Portuguese students got 525 points (524 in Numbers, 520 in Geometry and

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Measurement and 528 in Data), 25 points above the median of the total set (21st best place among the 58 participating countries), worst performing compared to the previous edition of 2015, where Portugal had obtained 541 points (13th best position). In terms of cognitive domains, the performance of Portuguese students was 523 points in the Knowing dimension, 528 in Applying and 519 in Reasoning.

According to the *Program for International Students Assessment* (PISA) of 2018, 79 countries / world economies participated and Portugal obtained 492 points in mathematical literacy, three points above the OECD average. This result of Portuguese students reveals a significant improvement in relation to the previous cycles of 2003 (466 points) and 2012 (487 points) and an improvement compared to the previous cycle of 2015 where Portugal obtained 491 points.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

2. MATHEMATICS ANXIETY

2.1. Definition

Anxiety is the thought of being worried and sad. In addition, it is expressed as a feeling of tension with an unknown cause, which comes with the thought that something bad will happen (Turkish Language Association [TLA], 2020). Kutluca, Alpay, and Kutluca (2015) define anxiety as being uneasy, hesitant, and afraid when the individual is confronted with the stimulus, although the individual does not know the reason. Aydın, Delice, Dilmaç, and Ertekin (2009) stated that anxiety emerges as a result of conflict and obstruction, and often reflects an unknown internal tension and uneasiness. Morgan (2019) also expressed anxiety as “a vague fear without knowing what the real problem is”. While anxiety appears with feelings of pessimism and hopelessness about the future, the anxious person feels physically and emotionally pressured and helpless (Alpay, 2004). In these contexts, anxiety can be expressed as a feeling of unknown cause, causing inner restlessness, and tension together with fear.

Scovel (1978) defined two kinds of anxiety as positive and negative anxiety. Negative anxiety affects students negatively and makes the learning process difficult. Positive anxiety enables people to be successful over their natural achievements. 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). Anxiety can occur in different areas of students. One of the areas where anxiety is frequently encountered is "mathematics".

Students' mathematics achievements are important in all areas of education, from primary education to university education. Mathematics questions have a very high effect on exam scores in all exams. For this reason, mathematics is a key point that will enable students to have a good education in the future (Şentürk, 2010). However, mathematics is one of the lessons that students have difficulty in learning, fail, dislike, and fear (Kutluca, Alpay, & Kutluca, 2015). There are many factors involved in students' failure in mathematics. These factors include negative attitude towards mathematics, negative beliefs, and mathematics anxiety.

The earliest studies on math anxiety began in the 1950s with Gough’s (1954) research. Gough (1954) was a teacher in primary school and investigated students’s negative emotional reactions during learning mathematical tasksand used the term “mathemaphobia" for these negative emotional reactions. Mathematics anxiety, which was first defined as "emotional reactions syndrome displayed against the field of mathematics and arithmetic" by Dreger and Aiken in 1957, did not attract the attention of researchers until the 1970s (Gündüz-Çetin, 2020). Richardson and Suinn (1972) offered the commonly accepted definition in upcoming decades. The feeling that disables people’s proper use of mathematical processes including problem solving and doing calculations in daily life and school setting were coined as “math anxiety” (Sarıgöl, 2019).

Mathematics anxiety, on the other hand, 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). In addition, mathematics anxiety is defined as a feeling of tension and anxiety in solving mathematical problems and using numbers in academic and daily life (Şahin, 2000). Baloğlu (2001) stated that mathematics anxiety is versatile and intertwined with concepts such as fear, worry, and uneasiness. According to Davarcıoğlu (2008), 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. An irrational emotional tray when an individual is required or expected to solve mathematics problems is also defined as mathematics anxiety (Aydın, 2011). In general, mathematics anxiety can be defined 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 behavioural manifestations such as tension, frustration, distress, helplessness, and mental disorganization. These characteristics show us math anxiety is generally modeled as a two-

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

dimensional construct in the literature. Not only cognitive aspect but affective issues are also important in the examination of math anxiety (Sarıgöl, 2019).

It is stated that 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). 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).

Other main reasons of the math anxiety can be listed as follows (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);

- 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.

It is stated that a decrease in self-esteem and pleasure, hopelessness, fear, and feelings of shame also significantly affect mathematics anxiety (Aydın, 2011). However, it has been revealed that it is related to self-efficacy and academic self-concepts (Schulz, 2005). In addition, a negative relationship was found between the mathematics anxiety levels of primary school pre-service teachers and their teaching confidence levels (Bursal & Paznokas, 2006).

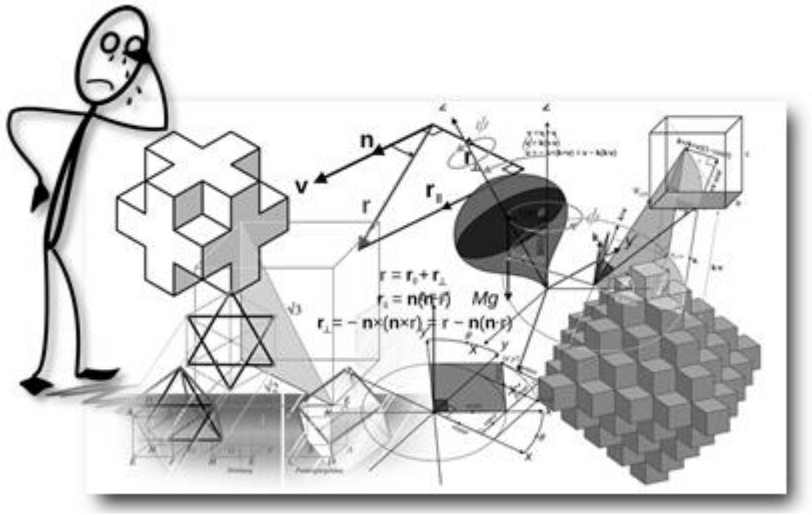
Anxiety is an emotion that is characterized by a set of reactions to a certain thing or context (Mendes & Carmo, 2014). These reactions can be unpleasant physiological (eg. Tachycardia, sweating, cold extremities), escape and avoidance behaviors, and production of negative self-attribution and negative attribution (Carmo & Ferraz, 2012: Mendes & Carmo, 2014). In the case of school mathematics, these reactions are common and can have several causes, highlighting, the difficulties experienced in their learning, and also the social conceptions about the discipline, which associate it with something not pleasant (Mendes & Carmo, 2014). In Portugal, and also in the Portuguese language research space, the theme of anxiety related to mathematics is not on the research agenda. Instead of looking at the negative side of the students' relationship with Mathematics, research in mathematics education has focused on creating rich mathematical experiences, which take place in pleasant environments. The HUMAT - Humor in mathematics teaching project (https://sites.google.com/view/humatproject/home) showed that Portuguese and Spanish mathematics teachers often use humor (i) to: create in environments that promote learning; (ii) create tasks that promote the learning of specific contents (Menezes et al., 2020). In addition, the HUMAT project team has created mathematical tasks based on comic strips, which are highly appreciated by students who learn mathematics in a good mood (Menezes et al., 2019; Menezes & Costa, 2020)

Mathematics anxiety can be defined as “concern, fear, and aggressiveness which emerge together with physical symptoms observed while dealing with mathematics” (Sherman, 1976). It can also be defined as “tension and anxiety feelings preventing to deal with numbers, solve daily-life problems and academical problems (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).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

MINDMATHS



Many students in our country think that mathematics is difficult. The number of students who think that they cannot achieve mathematics and develop a negative attitude towards mathematics is quite high. This situation starts from primary school and unfortunately continues to increase as the school years progress. As a result, students develop a negative attitude and self-confidence towards this important lesson. Worse; They come to the conclusion that they are not smart enough to learn mathematics and that mathematics is not among their favourite subjects (Baykul, 2002).

In order to enjoy the pleasure of mathematics, it is necessary to realize that mathematics is not an isolated subject that has little to do with the objects around us. Mathematics is not a subject that is used to find the balance of income and expense or that bores us with its complex calculations. Considering that mathematics is an important tool in solving problems in daily life, it can be said that in the planning of activities in mathematics lessons, it can be said that it should be related to the subjects in other lessons as well as the structure of mathematics (Baykul, 1998).

Math anxiety is a negative emotional reaction to math and numbers, feeding a vicious cycle of avoidance and ignorance. For Sheila Tobias and Carol Weissbrod (1980) is "the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" and it is thought to affect a large proportion of the population". Sheila Tobias has been known for her research in the areas of math anxiety and math and science instruction. For Ashcraft (2002), Math anxiety refers to "feelings of fear, tension, and apprehension that many people experience when engaging with Math".

Math anxiety is thought to be "a trait-level anxiety and is distinguishable from both test anxiety (Kazelskis et al., 2000) and state anxiety (Hembree, 1990). Apart from aspects like gender, age and culture affecting mathematics anxiety, research has shown that emotional factors, such as general anxiety or self-esteem play an important role too (Orly-Rubinsten & Tannock, 2010; Dowker et al., 2016). Math anxiety is highly prevalent, affecting nearly 50% of grade-school children in the United States alone (Beilock and Willingham, 2014). According to the Organization for Economic Co-operation and Development (OECD), 31% of 15-year-old students reported feeling nervous when solving a math problem and as many as 59% indicated that they were worried about math classes (OECD, 2013).

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). Notably, 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). Math anxiety has even been thought to operate similar to a phobia (Hembree, 1990; Pizzie & Kraemer, 2017), as brief exposure to math stimuli creates a behavioral disengagement bias similar to a fear-conditioned stimulus (Pizzie & Kraemer, 2017).

The conditions for math anxiety can be environmental (bad experiences, bad teachers), personal (lack of confidence, low self-esteem), dyscalculia, or cognitive deficits. Apart from aspects like gender, age and culture affecting mathematics anxiety, research has shown that emotional factors, such as general anxiety or self-esteem play an important role too (Orly-Rubinsten & Tannock, 2010; Dowker et al., 2016). But its precise developmental origins are still not known (Rubinsten & Tannock, 2010). Several causes probably come into play in this complex phenomenon that affects many millions of students worldwide.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

It can often hinder the successful completion of tasks involving manipulation of numerical information and is a prominent cause of problem-solving difficulties across all age ranges (Ashcraft & Krause, 2007). Because the detrimental impact of math anxiety on mathematical development is lifelong (Rubinsten & Tannock, 2010), it is important to understand its neurobiological origins, especially during the earliest stages of formal math learning in elementary school children (Young, Wu & Menon, 2012). 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.

In this Review Paper we briefly outline the main studies on math anxiety and some methodologies and interventions that expressed a good level of success.

2.2. Research/practices to release the mathematics anxiety of primary school children

Two ways are suggested to eliminate students' mathematics anxiety. These ways are indicated as counseling techniques and techniques for developing mathematics skills (Baloğlu, 2001). Mathison (1977; akt. Keçeci, 2011) evaluated the use of counseling techniques in mathematics anxiety. Researchers have found that these techniques were 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. However, several decades have passed since this study was conducted (Mathison, 1977; akt. Keçeci, 2011). For this reason, it can be recommended to conduct studies using psychological techniques to reduce math anxiety.

Another 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. In addition, 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 behaviour 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 behaviours 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).

It is stated that mathematics anxiety will have long-term effects such as timidity, loss of self-esteem and inferiority. For these reasons, early detection and elimination of mathematics anxiety will increase the chance to overcome it. In addition, it is recommended to refer students with excessive anxiety to guidance services and to try to reduce anxiety by cognitive restructuring (Keçeci, 2011).

To reveal the status of studies on the math anxiety of primary schools in Turkey, 61 graduate theses and published 81 articles were examined. When 61 graduate studies are examined; it is noteworthy that the studies have intensified after 2011. Especially in the last three years (2018, 2019, 2020), it is seen that math anxiety has been studied in 21 graduate studies.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

When the education level focused on postgraduate studies is examined; it is seen that approximately 69% of the studies are related to the primary education level. Especially when the last 3 years are examined; it is remarkable that 16 of the 21 graduate studies are related to the primary education level.

When both postgraduate and research studies published as articles are examined; the majority of the studies focused on examining students' mathematics anxiety levels according to various variables. Examining the surveys a total of 142 on the mathematics anxiety in Turkey as a result of the conclusions are as follows;

- The scarcity of studies on teachers and pre-service teachers; It shows us that there is no necessary sensitivity about teacher attitudes and teaching techniques competencies, which are the main causes of mathematics anxiety.
- It is seen that studies on math anxiety go beyond determining the existing situation and there is a lack of applied studies to the solution of the problem.
- It is observed that there are no studies regarding the teaching of different teaching techniques/ activities/ applications to reduce mathematics anxiety in students regarding pre-service teachers.

There is a huge importance to research about teacher math anxiety reduction for pre-service teachers. 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.

The second important factor creating mathematics anxiety is the fear of making mistakes in the maths classes (Zakaria ve Nordin, 2008). To release this fear, teachers should try to create a democratic supportive classroom environment.

Another factor causing mathematics anxiety is the negative attitudes and implementations of teachers during the maths 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;

1. Carry out various implementations to release maths anxiety in primary schools such as 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. Concretise abstract topics with modelling, visual examples and games (Ertem-Akbaş, 2018).

Math is an important topic in schooling, and knowing Math is an asset for careers; skill at math is often a filter in terms of career pathways. Today, mathematics is a language in its own right, the knowledge or ignorance of which can divert careers and job opportunities.

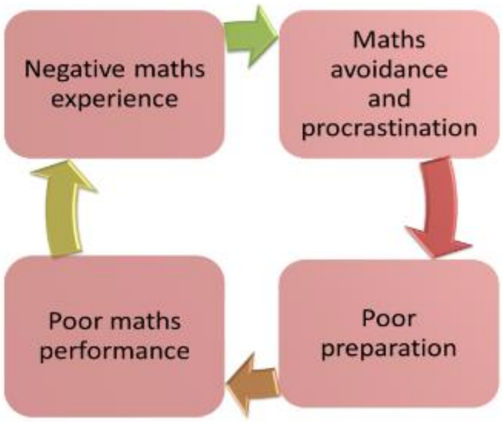
In the Western world the teaching of basic mathematics to everyone was triggered by the needs of the industrial revolution. Basic skills in handling currency, counting stock and such was required. During the Victorian era topics further expanded. In the UK it was the second half of the 19th Century that integrated the alignment with STEM requirements that we see to the present day. By the

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

beginning of the 20th Century mathematics was compulsory in all developed countries and most developing countries were at least heading the same way.

In terms of math anxiety, several implications for education can be drawn. Math anxiety seems to influence cognitive processing in a straightforward way - working memory resources are compromised whenever the anxiety is aroused. Given the pervasiveness of working-memory-dependent processing in arithmetic and math, this predicts serious effects of math anxiety (Ashcraft, & Krause, 2007).

The very abstractness of mathematical symbols surely adds to the difficulties that people encounter when learning math, including difficulties in storing and using information in working memory. Acquiring the capacity for abstract thinking, of course, is a late developmental milestone.



One possible approach to anxiety reduction is based on well validated studies of behavioral exposure-based therapy for anxiety disorders. Multiple meta-analyses have demonstrated the efficacy of exposure-based therapy for treating anxiety disorders including phobias.

Some authors (Supekar et al, 2015) carried out an intensive 8 week one-to-one math tutoring program to reduce math anxiety in elementary school children, a study in which Authors identified also the neurobiological mechanisms by which math anxiety is ameliorated in affected children. The conclusion of these successful interventions was that 8 weeks of intensive one-to-one math tutoring reduced in children negative emotional response to math and remediates aberrant functional responses and connectivity associated with math anxiety.

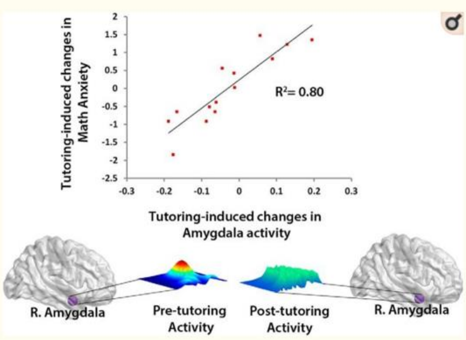


Figure 3.

Remediation of aberrant amygdala reactivity predicts tutoring-induced reductions in math anxiety. Eight weeks of one-to-one tutoring reduced math anxiety in HMA children and tutoring-induced reductions in right amygdala activity predicted individual reductions in math anxiety. These results remained significant even after covarying out pre-tutoring anxiety and tutoring-induced performance gains.

The most exciting aspect of our findings is that cognitive tutoring not only improves performance, but is also anxiety-reducing," said the study's senior author, Vinod Menon, PhD, professor of psychiatry and behavioral sciences. "It was surprising that we could, in fact, get remediation of math anxiety.

2.3. Account of some objectively-based studies

According to Vinod Menon (2012), and Ashcraft and Krause (2007), the first objectively-grounded researches on math anxiety began to be published in the early 1970s, and an objective

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

instrument for measuring maths anxiety became available. These studies showed a correlation between math anxiety increases and math achievement declines. This correlation was confirmed by the original work of Ray Hembree (1990), Associated Professor at Adrian College (Michigan), whose researches on math anxiety meta-analysis remains the forerunner for all the successive studies.

In his work, The Nature, Effects, and Relief of Mathematics Anxiety (1990), the results of 151 studies on College students, males and females, were integrated by meta-analysis to investigate the construct mathematics anxiety. The study showed that variables that could intervene in mathematics anxiety levels include ability, school grade level, and undergraduate fields of study, and previous arithmetic teachers especially prone to mathematics anxiety. The conclusion of the studies by Hembree outlined the following questions:

1. Does mathematics anxiety tend to contribute to poor performance?
2. Does knowledge of poor past performance induces the anxiety?
3. Or, is the relation circular?

And the results appeared to be:

1. Higher achievements consistently accompany reduction in mathematics anxiety;
2. Treatment can restore the performance of formerly high-anxious students to the performance level of associated with low mathematics anxiety:
3. The construct's relation with IQ and ability seem small.

Social conditions and conditionalities are identified by the study:

Across all grades, female students report higher mathematics anxiety levels than males. However, these higher levels do not seem to translate into more depressed performance or to greater mathematics avoidance on the part of the female students. Indeed, male students in high school exhibit stronger negative behaviours in both these regards. This paradox may be explained along two lines: 1) Females may be more willing than males to admit their anxiety, in which case their higher levels are no more than a reflection of societal mores; 2) females may cope with anxiety better. Whatever the cause, al precollege levels mathematics anxiety effects seems more pronounced in male than females students. (Hembree, 1990).

The line of development narrated by the correlations is sad indeed. The higher one's math anxiety, the lower one's math learning, mastery, and motivation; highly math-anxious individuals get poorer grades in the math classes they take, show low motivation to take more (elective) math, and in fact do take less math. They clearly learn fewer math than their low-anxious counterparts. In conclusion, Hembree states that, like any other text anxiety, mathematics anxiety "seems to be a learned condition more behavioral than cognitive in nature" (emphasis added).

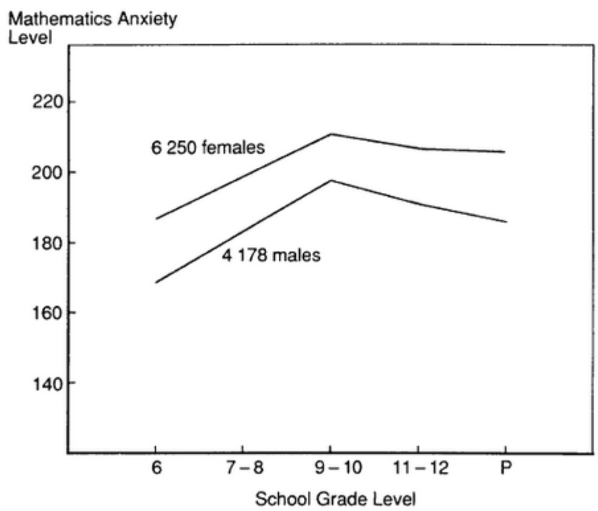


Figure 1. Average mathematics anxiety levels for Grades K–12 and undergraduate.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

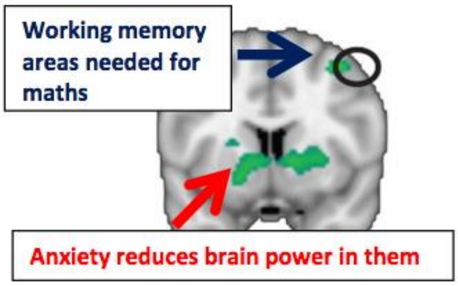
Another important study on math anxiety in adults is by Mark H. Ashcraft e Jeremy A. Krause (2007), working memory, math performance, and math anxiety, where Authors analyze the role of the working memory in the phenomenon of Math Anxiety in the 15 years literature on the subject.

Considerable evidence has appeared in the past 10 to 15 years concerning the vital role that working memory plays in mathematical cognition. The literature now supports a clear generalization concerning the important positive relationship between the complexity of arithmetic or math problems and the demand on working memory for problem solving. One aspect of this relationship involves the numerical values being manipulated, and one aspect examines the total number of steps required for problem solution. It is now clear that working memory is increasingly involved in problem solving as the numbers in an arithmetic or math problem (the "operands") grow larger. The benchmark effect in this area is the problem-size effect, the empirical result that response latencies and errors increase as the size of the operands increases. For example, 6 x 7or 9 x 6will be answered more slowly and less accurately than 2 x3 or 4x 5 (see Zbrodoff & Logan's 2005 review). Part of this effect, we have argued, is due to the structure of the mental representation of arithmetic facts in long-term memory, and the inverse relationships between problem size and problem frequency (emphasis added).

The lower achievement of math-anxious individuals seems limited to more difficult math, the math taught at or after late elementary school. When students have to deal with a more complex math, Authors argue that a math-anxious person's working memory resources are drained - that the individual suffers a compromised working memory-only when the actual math anxiety is aroused, as in span tasks that involve computations.

Furthermore, Authors results show that high-math-anxious participants often sacrifice accuracy for speed, especially as problems become more difficult, which we interpreted as an avoidance-like effort to finish the testing session as quickly as possible (Faust et al., 1996).

So far, relatively few projects have explored math processing beyond the four basic arithmetic operations, so the role of working memory at higher levels of math has hardly been investigated at all. Authors argue that based on the central role identified so far, however, it can only be the case that more difficult math will be even more dependent on working memory.



One Author who, with his group, has studied the phenomenon in a thorough and scientific manner is Vinod Menon. Professor of Psychiatry and Behavioral Sciences and of Neurology at Stanford University, he serves as director of Stanford Cognitive and Systems Neuroscience Laboratory, which is dedicated to the investigation of human brain function and dysfunction using a multidisciplinary approach that emphasizes a tight integration of cognitive, behavioral, neuroscience and computational methodologies. Students, staff and scientists in his lab come from multiple disciplines, to conduct research in a highly interdisciplinary setting. In the book The Neurodevelopmental Basis of Math Anxiety (Menon et al, 2012) it is said that:

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 are less likely to pursue science, technology, engineering, and math-related careers than those with low math anxiety.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

As the Erasmus plus Mind Maths project is aimed primarily at primary school children, the studies by Menon and his team are important as they have extended the survey to include pre-school children. We will consider in particular the work of Menon and his team.

Math anxiety during early childhood also has adverse long-term consequences for career choice, employment, and professional success (Hembree, 1990). Recent research has shown that childhood math anxiety is associated with aberrant functional responses in brain regions and circuits important for processing negative emotions (Young et al., 2012). Although the negative consequences of math anxiety are well understood, to date there have been few studies of interventions for remediating math anxiety in children. According to Young, Wu and Menon (2012) this is in part due to the lack of a developmentally appropriate measure of math anxiety. To address this issue, these Authors recently "extended the Mathematics Anxiety Rating Scale (MARS), a standardized method for assessing math anxiety in older children and adults, to create the Scale for Early Mathematics Anxiety, SEMA.

SEMA has been shown to be a reliable and construct-valid with Cronbach's α = .870) measure of math anxiety in 7- to 9-year-old second and third graders (Wu, Amin, Barth, Melcarne, & Menon, 2012). Cronbach's alpha (sometimes simply α coefficient) is a statistical indicator used in psychometric tests to measure their reliability, i.e. to verify the reproducibility over time, under the same conditions, of the results they provide. Generally, high reliability values are considered to be those ranging from 0.70 upwards.

Let's follow Young, Wu and Menon's study on children:

To examine the neurodevelopmental basis of math anxiety, we analysed functional brain-imaging data from forty-six 7- to 9-year-old children, which we obtained while the children determined whether addition and subtraction problems were correct (e.g., "2 + 5 = 7") or incorrect (e.g., "2 + 4 = 7"). In a separate session, we used the SEMA to assess math anxiety in each child. (..) We hypothesized that if children with high math anxiety view such stimuli negatively, they would show hyperactive amygdala response during math problem solving. Furthermore, amygdala connectivity with medial prefrontal cortex regions involved in emotion regulation would also be elevated when compared with such connectivity in children with low math anxiety.

The study results were very interesting:

These results provide converging evidence for aberrant processing within local functional circuits in the amygdala of children with high math anxiety. Children with high math anxiety also showed reduced responses in cortical and subcortical areas that have been consistently associated with mathematical and numerical reasoning in children and adults (Menon, Rivera, White, Glover, & Reiss, 2000). These differences were related to arithmetic complexity and were independent of sensory, motor, decision-making, or response-selection processes. Additional analysis using SEMA scores as a continuous variable confirmed the observed pattern of increased right basolateral amygdala responses and decreased frontoparietal activation with math anxiety. Furthermore, these effects occurred independently of individual differences in trait anxiety, working memory, and performance.

2.4. Conclusion

The finding of many of the studies cited is that math anxiety can be detrimental to learning in general and its effects can even be compared to those of a phobia. At the same time, several case studies show possibilities for remediation to math anxiety. Important steps are:

1. Early screening of everyone child to identify any issues like dyslexia and dyscalculia before negative experiences create self-confidence issues; kindergarten and primary school teaching of math applying modern ideas of active learning and appropriate context; integrate technology immediately and eliminate the teaching habit like times tables.
2. Primary school math is very suitable for gamification;
3. The first year of high school should teach math in context, what it actually does in society, its importance to our historical developments and the different ways math is actually used in the real world.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

3. USE OF ROBOTICS IN PRIMARY SCHOOL MATHEMATICS EDUCATION

3.1. General overview

Countries should increase their citizens' interest in science and technology so that they can continue their development and become leaders in the world. They can achieve this by incorporating information-communication technologies into education. For this reason, the use of technology in education has increased. However, it has begun to be seen that robotic applications are becoming frequently used as well as computers. With the increasing importance given to educational software, block-based programs and robotic kits enable young students to meet technology and engineering (Elkin, Sullivan, & Bers, 2016). Science, technology, and engineering education are tried to be taught from an early age with coding and robotics. In this way, it is tried to create a qualified workforce (Sullivan & Bers, 2016).

The educational use of robotic technologies first emerged in the USA more than 20 years ago (Chung, Cartwright, & Cole, 2014). It can be said that the use of robotics in teaching is an approach that enables students to put into practice the knowledge and skills they have learned from various disciplines (Ching et al., 2019). Robotic technologies can be considered as an excellent tool not only for robotics but also for applied learning in science, technology, engineering and mathematics (Mataric, Koenig, & Feil-Seifer, 2007). Robotic applications can also be used in solving problems related to ratio-proportion, integers, square root, algebra equations, trigonometry, measurement, estimation, and geometry in mathematics teaching (Stripling & Simmons, 2016).

Robotic technologies can be considered as mind tools that students use modern technologies to solve problems (Jonassen, 2000). These technologies encourage students to work collaboratively (Yuen et al., 2014). While students are learning with robotic technologies, they try to cope with a number of problems and participate in academic discussions with their peers to find a solution to these problems. In this way, robotic technologies encourage students to collaborate (Kopcha et al., 2017). In addition, it provides students with some skills in terms of discovering, structuring and applying what they have learned (Ching et al. 2019).

Robot models, programmed with computers, allow the acquisition of skills such as creative thinking, critical thinking, and computational thinking as well as high-level thinking skills (Korkmaz, Altun, Usta, & Özkaya, 2014). In addition, it has been observed that the use of robots in education has positive effects on students' cognitive, language, social, and moral development (Kahn Jr, Kanda, Ishiguro, Freier, Severson, Gill, & Shen, 2012; Kozima & Nakagawa, 2007; Shimada, Kanda, & Koizumi, 2012; Wei, Hung, Lee, & Chen, 2011). Along with these, the use of robotics in education has been effective in increasing students' desire for collaborative learning and activities (Chen, Quadir, & Teng, 2011; Highfield, 2010; Wei, Hung, Lee, & Chen, 2011). For this reason, the use of robotics in education has had a wide range of uses. It has been revealed that the studies conducted in this field are mostly carried out in secondary school, primary school, and pre-school period respectively (Yolcu & Demirer, 2017).

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. Thanks to this kit, they aimed to increase the problem solving skills of the students and eventually reached the conclusion that the students' scores increased. Providing more application opportunities to younger students with robotic kits is recommended in order to gain high-level skills (Yolcu & Demirer, 2017).

Mathematical knowledge contributes to the cultural formation of individuals and communities, developing the ability to relate 'thinking' and 'doing' and offering ''thinking' and 'doing' and by offering

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

tools for perceiving, interpreting and interpret and connect natural phenomena, concepts and man-made natural phenomena, concepts and man-made artifacts, everyday events.

In recent years, the method of teaching mathematics in primary schools in most parts of Italy has changed. Mathematics is both science and technology, and therefore, being considered a scientific subject, it goes hand in hand with technology. If technology becomes modern, the technological and non-technological methods of teaching mathematics will also change. Until about ten years ago, mathematics was taught in Italy according to an 'ancient' method, we can talk about teaching algorithms and formulas without a precise aim. What are the main limits of the approach that was traditionally followed? There remains a fundamental error in the way school work is set up: Anything other than lectures and written assignments on notebooks was often seen as a waste of time.

Nowadays, however, the method has changed, the tools have changed. We try to pass on the usefulness and practicality of what is taught. Specific and direct applications are sought. This is the only way to get the children's attention.

In Italy, as in all schools around the world, mathematics is taught from primary school onwards. The school's objective cannot be above all to pursue the development of individual techniques and skills.

The aim of schools cannot be to develop individual skills and competences; rather, it is to provide each person with a solid cognitive and cultural education so that they can cope positively with the uncertainty and change of present and future social and professional scenarios.

The uncertainty and changeability of present and future social and professional scenarios. The school is called upon to create educational pathways that are more and more to the personal inclinations of the students, with a view to enhancing. The school is called upon to create educational pathways that are increasingly responsive to students' personal inclinations, with a view to enhancing the particular aspects of each individual's personality.

There is no doubt that learning STEM subjects in early education can improve learning speed and provide a strong motivation later (Scaradozzi et.al, 2015). According to Scaradozzi et.al the use of robotic systems and introduction of Robotics can cover the need of teaching problem solving and technology as well as collaboration and teamwork.

A simple Google search can show that in Latvia there are a lot of robotics-based events and extra-curricular activities, nevertheless, there is almost no if no evidence that robotics would be used during mathematics education within schools’ programs on a regular basis.

Portuguese educational policies recognize the importance of developing digital skills from an early age. Curriculum guidelines for the 1st cycle of the Portuguese primary education system assumes Information and Communication Technology (ICT) as a cross-cutting area, challenging a significant based-curriculum approach to integrate ICT, fostering meaningful learning in the several curriculum areas. This movement goes beyond the narrow idea of preparing more well-equipped programmers and engineers, as it is a broader approach to empower children problem solving, creativity, communication or abstract thinking skills. In the last years there is a growing interest in Computational Thinking as a powerful and gathering idea to enable students to develop multidisciplinary skills, such as problem solving, decision making, teamwork, ethical sense and project management. Computational Thinking (Wing, 2006) applies to a large spectrum of disciplines and areas and involves the idea of solving problems, conceptualizing and thinking at multiple levels of abstraction. Computational Thinking is a thought process embracing elements such as abstraction, generalization, decomposition, algorithmic thinking, and debugging or evaluation.

Robotics gives children the opportunity to relate tangible concepts with programming and computational thinking. In this way 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 (Papert, 1993).

Governmental initiatives to introduce programming and robotics in the Portuguese primary schools are grounded and sustained in the development of Computational Thinking and Project Based Learning in a multidisciplinary and based curricula approach.

3.2. Mathematics and computational thinking

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Computational thinking is a necessary skill for all individuals regardless of what their professional focus is. Many would may 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 a valuable 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 in reality. 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.

3.3. Basic principles of the use of robotics in mathematics education in primary schools

Use of robots in teaching mathematics has been a topic of discussion for several years (Felicia, & Sharif, 2014; Zhong & Xia, 2020). Educational robotics provides teachers with a myriad number of opportunities to foster students’ various STEM-related skills (Khanlari & Mansourkiaie, 2015; Merdan,

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Lepuschitz, Koppensteiner, & Balogh, 2016). In their review of 60 publications from 2013 to 2017, Benitti and Spolaôr (2017) have found out that educational robotics help students learn many STEM-related concepts in all levels of K-12 education. They also found that teachers utilizing educational robotics encourage group work with a focus on problem solving. Benitti and Spolaôr (2017) conclude that educational robots have been effectively used in multiple STEM environments with different characteristics.

Applications of robotics education have been reviewed extensively (Bascou & Menekse, 2016). In a recent review of 147 research studies published between 2000 and 2018, it was found out that 45 studies out of the 147 reported some sort of general benefits of use of educational robotics in diverse settings (Anwar, Bascou, Menekse, & Kardgar, 2019). In a research study, Williams and colleagues (2012) found out that robotics education in an after-school program increased elementary school students' conceptual understanding in mathematics. Also, students' motivation and interest increased after their participation into the robotics education activities (Williams, Igel, Poveda, Kapila, & Iskander, 2012). In another study, Results of an experimental study (Ortiz, 2011) indicate that students in the experimental group, an active robotics education setting, improved their achievement in ratio and proportion significantly. Yet, the students in the passive text-based control group also significantly increased their scores in the same domain. What is interesting is that students in the experimental group showed higher mathematics performance than the students of the control group in an engineering-related context (Ortiz, 2011).

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). Last but definitely not least example is research that has shown improvements of several early school leaving risk indicators within high-risk students (Daniela & Strods, 2019a) such as students' motivation and attitude. All mentioned uses of robotics deal with some of most widespread problems that teacher can face in classroom.

The methodology mostly used in Italy in primary schools for teaching Mathematics is the PP&S (Problem & Posing Solving), in the belief that a traditional teaching/learning of Mathematics does not allow to understand its pervasiveness, its depth and its important applications in everyday life. The PPS is one of the methods that can most easily be combined with robotics. Robotics is used in this and all following applications as a teaching tool. Mathematics, being a scientific subject, is thus well complemented by robotics. 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 methodology consists in starting from a real situation in order to stimulate the ability to solve a problem after having paid attention to its posing: the student is not limited to the mechanical application of learned formulas and pre-packaged recipes but is confronted with a problem that cannot be traced back to something known, nor is he in possession of the method that leads to the correct result. This method is found at the end of a research path in various stages, from the reduction of the problem into simpler and more easily solvable parts to the assumption of new points of view and different possible directions.

Multiplication is introduced at the beginning of primary school, but its properties are usually introduced after rote memorization of multiplication facts. In primary school, the basic concepts of the various calculation operators are taught. From multiplication to division and from subtraction to addition. All these concepts, however, need an application, and before that they need a practical reality. In Italy, the concept or rule is often derived from practical experience. Visual calculation is one of the most important lessons introduced in primary school. Placing two quantities side by side to estimate the sum or deleting an object to introduce subtraction. In this way, it will be possible to introduce much more difficult and at first glance abstract concepts such as pygreque.

One way of introducing the concept of the pygreque to primary school children is to use a string and see how many times I have to multiply the diameter to obtain the perimeter of a circle. Again, I can represent 3 squares constructed with the diameter and calculate the area of that same circle. So that's what is meant by visual calculation and learning from practical experience.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

One of the most important issues in mathematics education research concerns language. Language, a cultural artefact par excellence, plays a fundamental role in learning processes and classroom practices, as widely recognized in numerous literature studies.

A large proportion of students' failures can be attributed to language problems. To understand the comprehension difficulties that many students encounter in mathematical activities, a cognitive approach is needed: it is important to investigate what characteristics underlie the diversity of mathematical processes. Mathematical activity is characterized by the dominant importance of semiotic representations and their great variety. Understanding in mathematics presupposes the coordination of at least two registers of semiotic representation. Such coordination does not come naturally to students.

Primary school pupils in Italy have a good level of competence in mathematics: this is the picture that emerges from the international Iea TIMSS 2019 survey, which overall sees an improvement in mathematical skills. TIMSS report, Italian students better in mathematics but female students improve. Dialogue with Laura Palmiero (Invalsi) INTERVIEW

Overall, Italian fourth grade students achieve an average score of 515 in mathematics, significantly higher than the international average and similar to that of 12 other countries, including Germany, Sweden, Poland, Bulgaria, the Slovak Republic, Croatia and Serbia.

According to the survey, there is a significantly positive difference in number content (7 points higher than on the total scale in mathematics) and a significantly negative difference in geometric figures and measurement and data representation (-5 points and -17 points respectively) for IVth grade students.

As a result, Italian fourth graders know essential mathematical and robotics concepts and properties of mathematical thinking to an extent that is not significantly different from their overall mathematical abilities, while they are on average better at applying this knowledge (only 2 points higher on the application-specific scale than on the total mathematics scale, but the difference is significant).

The greatest difficulty for our students is in logical and systematic thinking, with a specific disadvantage in the domain of reasoning of 11 points compared with their results on the overall mathematics scale. These gaps are found in every macro-area.

On the other hand, as far as the Advanced level is concerned, i.e. where pupils are able to apply their understanding and knowledge in a variety of relatively complex situations and to explain their reasoning, it should be noted that only 7% of students internationally reach this level. In Italy, the advanced benchmark has been calculated for only 4% of pupils.

3.4. National and private initiatives for the use of robotics

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 reduce psychological and cultural barriers that prevents them from engaging in these fields.

In Italy many initiatives related to mathematics and robotics are organised. The Italian Mathematics Olympiad is an annual competition revolving around six mathematical problems. The Mathematics Olympiad is promoted and financed by the Directorate-General for School Regulations and the Evaluation of the National Education System and is managed, by agreement, by an educational institution or body that has been awarded the ordinary restricted procedure.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

The Italian Mathematical Union (UMI) guarantees from a scientific and educational point of view the implementation of the initiative both at national and international level and has managed the previous editions of the Olympiad by means of an agreement following the award of the tender.

Scuola di Robotica, in collaboration with Miur, is ready to launch the sixth edition of the Robotics Olympiad. The free competition is dedicated to selected students from upper secondary schools and aims to promote, encourage and support the educational potential of robotics with particular reference to STEM subjects. The main theme of the 2020/21 edition will be the environment and the projects presented will have to identify solutions for improving environmental conditions. Teams can choose to create robots operating in aquatic, terrestrial or aerial environments. And finally, the First Lego League, a robotics competition that confronts students with problems that can be solved using mathematics, science, technology and robotics.

Starting from the 1st September 2020 a new standard of education is being introduced in schools in Latvia within the project School2030 (Skola2030, https://www.skola2030.lv/lv/skolotajiem/izglitibas-pakapes/pamatizglitiba). This school year (year 2020/2021) 1st, 4th, 7th and 10th grade students started to study using the new standard of education. In this standard a new subject – computing is introduced. During 1st to 3rd grade students learn computing integrated in other subjects, starting from 4th grade it is a separate subject. Computing includes computer literacy, netiquette, algorithmic thinking as well as computational thinking and much more.

As was mentioned above, through 1st to 3rd grade, computing is integrated in subjects such as art, social studies and, most importantly, mathematics. For instance, in 1st grade students are learning linear algorithms during mathematics lessons themes 'How to tell and show: how much, where, which?' and 'How can the task be completed using an algorithm?'. In the second grade, more complicated algorithms are introduced during mathematics lessons. Starting from the 4th grade students have separate subject Computing where at least one third of learning time is devoted to programming. Based on schools' equipment teachers can choose to teach graphic programming language and/or robotics.

A project of University of Latvia ‘STEAM Masterminds’ (https://www.siic.lu.lv/projekti/pratnieku-laboratorija/) is an example how mathematics, robotics (programming) and science is connected. During this project specialized and coherent curriculum for 4th to 6th grade students was created (France and Bertule, 2019). Curricula is dived into modules, each of them has its own theme. Students learn about that theme from many different sides and knowledge that they gain during mathematics are used in robotics and/or science. All lessons from the module are connected and synchronized as much as possible. For instance, when students learn module ‘Car racing’ during Science lessons they build simple cars (balloon powered car etc.) and model their own car using knowledge from Mathematics lessons where they learn how achitects work. During programming students make car racing game in Scratch or make race robots – students’ need to program a Lego EV3 robot that it can drive the track.

There are many private initiatives for the use of robotics, for instance AlfaRobot, RoboHUB, RoboScientists, LearnIT and many more, that mostly provide extracurricular activities for students, basing on their gained knowledge and deepening it. At the moment during robotics lessons mathematical skills and knowledge is improved, not vice versa and it is important to mention that in most cases these activities are not free of charge.

In Portugal the ministry of education launched an initiative entitled “Introduction to Programming in the 1st cycle of basic education”, aiming to develop Computational Thinking, digital literacy and transversal skills (IniProg, 2017). This pilot project last for one school year, involving 27.000 student´s in the 3rd and 4th years of schooling and about 670 teachers. The initiative has been extending to the following school, seeking to increase the number of students and teachers involved (Bocconi, 2016). The guidelines designed for teachers’ points out goals and methodological approaches that should frame the activities in schools. We highlight some of the stated goals. Students should be able to: understand and apply fundamental principles and concepts of Computer Science; decompose and solve problems; apply algorithmic thinking; create animated stories and build games using computer programs; work in collaborative projects; evaluate their work. In a methodological perspective projects should draw upon different curriculum areas, students should work in groups to build their projects, creativity and diversity should be encouraged, as well as sharing

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

their projects with others. An evaluation report (Ramos e Espadeiro, 2016) recognizes that only 14.6% of the participant teachers worked with robots, although 77.8% worked with *Scratch* and 41% with *Kodu*.

The initiative “Probótica”, programing and robotics in basic education (Pedro et al., 2017), followed this first two year project, which ended up involving more than seventy thousand students. In a similar way it favors skills and competences across the curriculum based on learning scenarios that can make learning more active and meaningful. The initiative recognizes that in contextualized and challenging activities, robotics has an extraordinary pedagogical potential for approaching multidisciplinary themes and concepts in a practical, tangible and motivating way. Robotics provides a deeper learning of technology, fostering students to “learn by doing”, in a tactile way. Gathering technology, programming languages and tangible objects students can explore problems and visualize results. Thus the initiative aims to contribute to the development of skills associated with computing, increase students' digital literacy levels and promote transversal skills to the curriculum. The guidelines suggests to address computer science in the areas of Computational Thinking and Algorithm and Programming and Robots, to boost the development of the key competences for 21st-century learners, the “Four Cs” (Creativity, Critical Thinking, Communication, and Collaboration).

Alongside the ministry of education has supported the creation and development of programming and robotics clubs in basic and secondary schools in Portugal. The national database has 342 records. The Ministry of Education financially supports 156 clubs (Ministério da Educação, 2020).

In a local context, the project Smart City Lab for Kids outcomes from a partnership between the School of Education of Viseu and the municipality of Viseu. The main goals were focused on working computational thinking and creative computing with Viseu primary schools children, anchored in the following guidelines: project-based and based curriculum, exploring the potential of computational thinking to develop integrated and contextualized learning; collaborative work; creativity and diversity. Three hundred and forty six students and twenty teachers used programming and robots to explore and present ideas to turn their city a smart city. Students presented a diversity of proposals such as games to explore the rehabilitation of the river of the city, programmed robots to care for community gardens or to model an intelligent building (Gomes et al., 2019).

3.5. Other applications (serious computer games, VR, AR, etc.)

More and more countries around the world are adding robotics courses to their curriculum and encouraging the opening of after-school robotics courses (Mataric, Koenig, & Feil-Seifer, 2007). Considering the smart toys, smart watches, smart phones, smart refrigerators, smart cars and smart homes in the environment where today's children live, the use of robotic applications has emerged as a necessity in creating these learning environments (Çınar, 2020).

Many robotic education sets such as Ardunio, RoboRobo, Cebot, KiwiRobotic, LEGO Education Mindstorms (NXT, EV3, WeDo), 3D Printer, KIBO Robotics, Lego MoretoMath, Makeblok (mbot, neuron, codey rocy), Bee-Bot, Robotis Dream, O-BOT, Vex (IQ, edr) Makey Makey are there to provide coding and robotic training to all age groups. These sets have both block-based and text-based programming languages (Talan, 2020). While C, Java and Python are text based programming languages; Alice, Code Org, Modkit, Enchanting, Robo Pro, Open Roberta, Arduino (S4A), Blocky and mBlock are block-based ones (Akman-Selçuk, 2019; Costelha & Neves, 2018; Kalelioğlu, Gülbahar, & Doğan, 2018).

Block-based programs are different from complex code blocks in other programs thanks to their drag-and-drop structures. For this reason, they make it easier for young children to learn algorithm and programming. It has been stated that block-based programs fulfill most of the tasks involving algorithm and programming concepts of young students (Strwahacker & Bers, 2015).

Lego robot kits, produced by Lego company, appealing to various age categories and having many different models, have positive effects on students' problem solving and high-level thinking skills (Özdoğru, 2013).

Basic Arduino kits are frequently used to provide high school and more proficient students with programming skills. These students are in formal operational stage because in order to use Basic Arduino kits, students need to know and apply concepts such as circuit and resistor (Yolcu & Demirer, 2017).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Lee, Kafai, Vasudevan, and Davis (2014) conducted two workshops with middle school students using Makey Makey and Scratch. As a result, they stated that these educational robot kits positively affect the process by providing a gamified learning environment.

Lee, Kafai, Vasudevan, and Davis (2014) conducted two workshops with secondary school students using Makey Makey and Scratch. As a result, they stated that these educational robot kits positively affect the process by providing a gamified learning environment. Avcı and Şahin (2019) examined the effect of Lego Mindstorm projects on pre-service teachers' problem solving skills and scientific creativity. During the nine-week practice process, pre-service teachers faced with various problems and produced solutions to these problems with Lego EV3 Education sets. As a result, pre-service teacher defined these sets as creative, functional, applicable in education, developmental and able to apply knowledge. At the end of the projects carried out with the Lego EV3 sets, the results of the pre-service teachers' problem solving skills and scientific creativity were obtained.

Augmented reality, like many other robotics tools, has a scientific and particularly mathematical basis. In order to create an augmented reality scenario I need to have scientific and technical skills. On the other hand I can also propose scientific topics like mathematics through applications and scenarios of augmented and virtual reality.

Nowadays there are a lot of games and other applications that claim to be educational, however when it is time to choose language barriers and other problems pop out and exclude a lot of offered. One of the most exciting application that also teaches something new, is mostly free and in Latvian is *Roadgames (*https://www.roadgames.com/lv*)* application. It includes AR elements (one must find hidden treasures), as well as strong educational aspect (each game has at least one aim connected to gaining new knowledge).

For learning Latvian, the Latvian Language Agency has developed a site *Māci un Mācies* (https://maciunmacies.valoda.lv/) where games for various different groups based on age and knowledge background can be found. Also, great educational games about security in the Internet can be found on site drossinternets.lv (https://drossinternets.lv/lv/info/izglitojosas-speles-uzdevumi). Of course, there are games for learning mathematics (http://www.cirkulis.lv/matematika/). Nevertheless, most of the games have very simple interface and provide simple skills and knowledge to learners.

In the Portuguese context a few projects used electronic sensors to explore the environment. The Eco-sensors4Health Project is centered on the use of electronic sensors by children to become agents in the creation of healthy and sustainable environments in schools. In this project, children, form Viseu and Lisbon primary schools, acquired environmental health data with the sensors, using tablets or mobile phones. With the support of a collaborative platform they organize and interpret data form their school and search and visualize environmental health data from different schools (Silva, 2020).

In a similar approach the School of Education of Viseu, in collaboration with de municipality of Viseu, developed a project with primary school children to study and understand agricultural cycles with an economic impact in the county. Children used electronic sensors to collect important environmental data to understand how it affects the growing of plants such as the vineyard or the flax plants (Gomes et al., 2016). These activities foster the development of mathematical skills and abstract thinking through technology.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

4. BLENDED LEARNING APPROACH & FLIPPED LEARNING

4.1. Blended learning approach (theoretical knowledge)

Blended learning is an arena of instruction that combines traditional or non-traditional offline teaching mediums with online tools. As it is called, it smoothly blends face-to-face instruction with online instruction. When one delves into the details of a blended learning environment, she would see that there is not a clear distinction between the face-to-face and online aspects. Both mediums of instruction are seen as closely connected and blended components of a system that is deliberately designed to support learning. We see that the blended learning environment provides a unique opportunity for the learner to engage in learning tasks in face-to-face and online settings. Blended learning allows the learner to take the advantage of both mediums. Blended learning is not a fantasy or not an alternative to traditional face-to-face instruction, which is a necessity (Tucker, 2012).

Blended learning invites instructors to utilize more than one medium of instruction to enhance tehir students' learning of the content. It offers a variety of solutions to teaching problems. For example, online tools allows the learner to reach the content wherever they are at their convenient times. Considering the fact that we all are experiencing difficult days of Covid-19 Epidemic throughout the world without access to the luxury of face-to-face instruction, blended is seen as a viable instructional environment more than ever before. Indeed, in such challenging days, it is not possible to conduct blended learning without the face-to-face learning; however, educators and all other stakeholders have seen how powerful the online learning environments can be. The pandemic taught us how effective we can use the online platforms to further individuals' learning. Perhaps, lack of the face-to-face instruction does not allow educators to reach their full potential; yet, they are able to use the online environment much more than ever before. As a result, the Covid-19 disaster has been an opportunity for all educators to deeply understand benefits of online teaching. Online teaching will most likely be a natural part of formal education even after the pandemic is gone. Hence, we can surely proclaim that blended learning is the future of teaching and learning.

Effective instruction does not depend on a single method and medium of instruction. We should take advantage of whatever available for a better instructional system. Having said that, blended learning is presumably one of the most effective way for reshaping the education of future. It is arguably what future educational systems will be used for all kinds of formal learning environments, including K12 education and beyond (Wilson & Smilanich, 2005).

For teachers and students, blended learning is a feasible way to engage in educational activities both in face-to-face and online environments. It gives them the flexibility that is necessary for high quality instruction. Teaching is not limited to the walls of the classroom; yet, under pandemic conditions teachers and students even do not have access to the traditional classroom conditions. It is an irony that prior to the pandemic, it was usually a challenge to utilize online learning tools; on the contrary, current conditions do not help any of the educators meet with their students face-to-face. For optimum learning, when the pandemic is gone, both face-to-face and online settings will be available so they should be blended for enhancing individual learning. Blended learning allows the teacher to utilize benefits of each mode of communication. Each has its own unique features and advantages with particular challenges; thus, educators will extend the length and quality of learning by focusing on strengths of face-to-face and online settings. From now on, teaching does not necessarily begin face-to-face; but, students can begin learning the basics of subject matter online and tackle the applications during the face-to-face time. With blended learning, the meaning of classroom is no longer a brick and mortar physical structure. It is more than that. Online classrooms are likely to be acknowledged as official place of learning (Tucker, 2012).

It is the instructor who decides which learning objectives are more suitable for either of the learning environments. While some learning goals and instructional tasks are more appropriate for the face-to-face setting, some others are better for the online side of it. With experience, the instructor would know what to do if they meet face-to-face and what is most appropriate if it is time for online activities. Learning does not start or finish at traditional classrooms. It is just one of the venues to facilitate student learning. People can easily engage in formal learning when they are away from the physical presence of the teacher. In a well-designed system, the learning is achieved regardless of the setting whether it is physical or virtual. Instruction needs the interaction among all related parties,

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

including the instructor, students and the content. It is not surprising that such interaction is carried out online as well as face-to-face (Hofmann, 2018).

Keeping in mind what has been said so far, we should also declare that without the face-to-face component instruction will be lacking a critical part of blended learning. Indeed, there would not be a blended learning unless there is the face-to-face feature; like what we have during the pandemic days. There is always demand for a better education. It should also be well-agreed that the time spent in school is not enough or not suitable for some learning goals. This hybrid way of schooling seems to be a way to illustrate what education is supposed to be. When we have limited time and resources, online tools are big help for making our hands stronger to fulfill the promise of education for all (Tucker, 2012). Equity is better addressed in blended learning environments as students find more opportunities to learn at their own pace at their convenience.

There is plethora of information available through online resources such as videos, articles, podcasts, pictures and interactive applications. Each has the potential to touch on a different section of brain cells for learning the subject matter. During the face-to-face time, it is never possible to get benefit of those rich resources even with the support of the teacher. Yet, under the guidance of the teacher, the learners can take more benefit of the online resources to further their learning. Students can work together with their peers to work on class projects, discuss their questions and exchange their ideas through synchronous and asynchronous communication tools with the convenience of participating in class work wherever they want (Tucker, 2012).

Driscoll (2002) defined blended learning from four different aspects as follows.

1. To combine or mix modes of web-based technology (e.g., live virtual classroom, self-paced instruction, collaborative learning, streaming video, audio, and text) to accomplish an educational goal.

2. To combine various pedagogical approaches (e.g., constructivism, behaviorism, cognitivism) to produce an optimal learning outcome with or with out instructional technology.

3. To combine any form of instructional technology (e.g., videotape, CD-ROM, web-based training, film) with face-to-face instructor-led training.

4. To mix or combine instructional technology with actual job tasks in order to create a harmonious effect of learning and working.

Thus, blended learning can be defined as combining face-to-face in-classroom teaching methods and techniques with distance learning methods and techniques to accelerate learning and provide students with learning anywhere and anytime. Another description of blended learning is “the thoughtful integration of classroom face-to-face learning experiences with online learning experiences” (Garrison & Kanuka, 2004).

Distance education practices of the blended learning can be useful for teachers and students when online solutions come into prominence such as the COVID-19 outbreak which we all experience these days. Virtual classrooms and teleconferences for group works are effective solutions which can be replaced by face-to-face classroom practices.

Since the end of the 20th century and the early years of the 21st century, the widespread use of digital technologies has led to a review of education systems with the aim of achieving lifelong learning, i.e. lifelong learning that "embraces all aspects of life and takes place in every place of life (not only in formal learning spaces such as schools, universities, research centers, etc.)". This new educational strategy includes e-learning, i.e. the possibility of using the Internet to learn at a distance, eliminating the need for physical presence in a given context.

This has been made possible by the enormous development of the Internet since the late 1990s, which has reinforced a phenomenon of renewal of the "production of scientific knowledge" (Gibbons, Limoges, Nowotny et al. 1994). In fact, the advent of the Internet has led to an exponential increase in virtual communities and networking, which has led to a growth in interpersonal relationships and knowledge. In addition, the ease of sharing has made it possible to pool different knowledge and share ideas and projects even in different parts of the world.

With the arrival of Web 2.0 in the early 2000s, 'users became more and more subject-authors in a context of sharing or collaboration; the Internet is less and less a place where people search for

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

information and more and more a place where they build personal contents with tools such as blogs and wikis, share resources and communicate in more engaging ways through tools such as instant messengers, podcasts, photo or video sharing services'.

All this has had an inevitable impact on school and learning systems, including certain theories such as the constructivism theorized by Jean Piaget and applied to learning theories by Seymour Papert during his time at the Massachusetts Institute of Technology in Boston.

"A former collaborator of J. Piaget, together with M.L. Minsky, with whom he worked at MIT on research into artificial intelligence, he devised the first version of the programming language Logo. He developed a pedagogy (constructionism) according to which learners themselves contribute to constructing concepts by interacting with appropriate materials, called cognitive artifacts, which, used in a cooperative environment under the guidance of the teacher, facilitate learning; even the computer becomes a material for developing this process."

"If a man is hungry you can give him a fish,
but better still is to give him a fishing line and
teach him to fish."
S. Papert

Blended learning has been known and is actively developing since the 1960s (Pappas, 2005). This learning approach may include various activities such as face-to-face and online sessions, written assessments, reading assessments, group work and/or individual assessments (face-to-face and/or online), online discussions and many more (Allan, 2007). That means blended learning does not always have to include web-based activities, it could be fulfilled just by changing places, e.g. classroom, school yard, field trip, as well as changing methodology of the learning process.

Blended learning approach includes a lot of planning before the learning process and it is important to acknowledge that the teachers should review the content piece by piece in order to find the best possible and most meaningful delivery method not vice versa (Hofmann, 2011). At first this learning approach is going to take a lot more planning time however as a result student will be able to develop in many different planes and improve competencies such as communication, responsibility, creative and critical thinking etc. The teacher needs to plan out every activity in order to promote meaningful learning in a way that makes both the training space and the time flexible as a result achieving quality training (Gutiérrez-Pérez & Martín-García, 2020).

In Portugal, initial teacher education from early childhood education to secondary education leads to a teaching qualification at the respective level of education or teaching. A Masters' Degree is the qualification level required for all teachers. The initial training aims to provide candidates with scientific, technical and pedagogical skills and knowledge for teaching along the following professional dimensions: professional, social and ethical responsibility; teaching and learning; participation in school and community; and lifelong learning.

Universities and polytechnics provide initial teacher education. For early childhood, primary and some areas of post-primary (2nd cycle of Basic Education), the route is a 1st cycle in Basic Education and a 2nd cycle/Master Degree that works as a specialisation in the chosen levels of education: Early Childhood Education (ECE) only, Primary Education only, combined ECE and Primary Education, or Primary Education combined with Mathematics and Natural Sciences or Portuguese and History and Geography of Portugal. The first cycles are focused on the knowledge required for teaching in the content areas and subjects; the second cycle should also offer general educational knowledge, specific didactics of the teaching areas, and the deeper and larger experience of practicum in educational contexts. The practicum includes observation and collaboration in education/teaching situations and supervised practice in the classroom with experiences of planning, teaching and assessment. The practicum or supervised practice is a professional-type internship with a final report, usually involving some research work or reflection on the experience.

For continuing teacher education, there are different kinds of activity that are recognized: training courses, training workshops, study circles, short courses, conferences, as well as internships and projects. Continuing teacher education is organised by different entities: higher education institutions, training centres run by school associations, municipal and inter-municipal initiatives; not-for-profit professional or scientific association training centres; and Ministry of Education central

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

services. Teachers get involved with continuing teacher education on a regular basis as there is a minimum of training hours per year that need to be accomplished (in public schools).

Initial teacher education has a strong tradition in higher education, in Portugal, for teachers of all levels. Since 1998, Early Childhood Education (ECE) and Primary Education teachers have the same qualification as all other teachers, but even before then, the requirement was a Bachelor’s Degree from a Higher Education Institution (HEI). For continuing teacher education, the providers are more diversified but there is still significant offer from HEI. Blended learning in this context is, therefore, framed by the legislation for Higher Education. Before 2019 (Decree 133/2019), only the Open University could offer distance learning programs. But there is now the possibility for any HEI to offer distance education programs. Decree Law 55/2018 and Ordinance 359/2019 also make it possible for distance education to be an option in the non-Higher Education Portuguese educational system. For HE programs, if there is less than 75% of distance education activities, HEI have autonomy to propose and manage their teaching and learning activities, within the limits defined by National Accreditation Agency. There is, therefore, the possibility for blended learning courses in any Higher Education program.

Currently, in Portuguese system, both Universities and Polytechnics have e-learning initiatives, at least those focused on the use of on-line platforms as a complement to the face-to-face (f2f) experience (Pombo, 2014). According to the author, there are also many blended learning opportunities pervading Portuguese Higher Education. In its strongest sense blended learning involves combining sessions of face-to-face interaction with forms of online interaction (Laurillard, 2015), which is signalled as an advantage since it allows access to training to geographically dispersed populations as well as the temporal flexibility that allows particular audiences to overcome temporal limitations. Furthermore, HEI adopt b-learning for reasons such as: i) they recognize that students may not be able to deal with a fully online course; ii) they wish to introduce students to technology; iii) they propose to offer extra support to students; iv) they intend to reduce the f2f component of the teaching so that part time students and those with family responsibilities have better access to learning, or v) for financial and staff management reasons (Harding, Kaczynski & Wood, 2005, in Pombo & Moreira, 2013).). It also allows for a more flexible education, which can respond to the increasing diversity of students in teacher education (Irvine et al., 2013).

For this paper, we looked into courses and projects that have been the focus of research. We reviewed scientific papers and PhD Thesis that looked into blended learning in either initial or continuing teacher education. The flipped classroom approach has been used in Portuguese Higher Education (Costa, 2019; Loureiro et al., 2020; Pinto, 2018), but there are no studies about it on teacher education programs. The review, besides proving the possibility and opportunity of blended-learning in teacher education, provides some insight into important dimensions of developing blended learning for teacher education in Portugal.

Looking into initial teacher education, there are practices in teacher education associated to larger initiatives of some HEI, like in the University of Porto (Queirós et al., 2012). Several tools are used, in different combinations, recently articulated in e-portfolios. Overall, the students enjoy and learn significantly from the blended learning courses and consider that learning with digital tools also means learning about the pedagogival use of those tools. More focused on the specifics of teacher education, the work by Chélinho (2019) looked into blended pedagogical supervision in Early Childhood Education, researching on-line strategies of supervision together with the f2f strategies. The Colabor@ platform, designed for the purpose, revealed itself a reflective and articulating 'inter-place' between concrete practices and their critical analysis, developed through sharing and debating experiences and references; and also an opportunity for autonomous but joint construction of professional knowledge. Equally particular to teacher education but with a larger coverage in terms of the training experience, Loureiro (2019; Mattar Neto et al., 2019) analyses the implementation of a B-Learning Master’s Program in Digital Resources in Education.

There are several experiences of blended learning experiences for continuing teacher education in the last years, some of which have research work connected to them (Amante et al., 2019; Cruz, 2013; Freitas, 2015; Gonçalves & Osório, 2018; Oliveira, 2013; Souza et al., 2020). These range from short or medium duration workshops to courses connected to postgraduate degrees. In terms of content, the blended learning component is associated with special themes, like sex education for ECE and Primary Education (Freitas, 2015). or Education for Sustainable Development (ESD) (Cruz, 2013), or Computational Thinking, Programming and Robotics in Basic Education (Amante et al.,

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

2019; Souza et al., 2020). These themes are conceived and studied in combination with training for technology in teaching and learning, since several tools are used and seen explicitly as part of the training. Gonçalves and Osório (2018) looked specifically into the development of teacher's knowledge adopting the Technological Pedagogical and Content Knowledge (TPACK) referential. The studies describe the creation of training spaces that allow the integration of technologies in the teaching practice through the blended learning experience.

This strong idea that cuts across the several studies: it is important to implement blended learning in teacher education because teachers need to work in relevant ways with technology. There is a plea for isomorphism: teach the teachers, especially the future generation, as they are told they need to teach the young generations. The focus on technological pedagogical knowledge is, therefore, a strong dimension of the set of studies that we have reviewed.

A second dimension is the overall satisfaction of the learners. There seems to be motivation, knowledge and flexibility to use blended learning approaches in teacher education, even with older teachers in continuing education. In some studies, because the training allowed for mixing teachers from different areas of the country, that was addressed as a plus for the blended learning opportunity.

A third dimension is the diversity and articulation of digital tools: different platforms are used, but also social media and other interaction mediators. The focus is on communication, discussion and accommodating different media (text, video, animations, photos, audio recordings, drawings, mind maps). The diversity is driven by the needs of the teaching and learning but also seen-by teachers and students-as an advantage in terms of training.

4.2. Blended learning practices in primary school mathematics education

When the master's and doctoral dissertations and articles on blended learning were examined, no studies were found at primary school level in Turkey. The studies are summarized as follows:

Ünsal (2007) analyzed the effects of blended learning on students' motivation and success. The lesson that planned according to blended learning approach evaluated in dimension of behavior, success and reaction. According to blended learning approach both web based and face to face learning environments designed and effectiveness of blended learning approach is evaluated on multiple levels. Akkuş (2014) attempted to understand the effects of a blended learning environment on teaching differential equations and also to determine the advantages and disadvantages of a blended learning method. In this study, a course of differential equations was prepared with a syllabus and related materials according to the blended learning model.

In another study Pesen (2014), performed a study to examine the effect of blended learning environment on academic success, studying habits, and motivation of pre-service teachers. In this research totally 158 students took part from Mathematics Teaching and Social Sciences Teaching divisions from a public university. Ceylan (2015) researched the effects of blended learning, which provides more effective learning outcomes gains through enriching todays developing Web Technologies with learning environments, on the middle school level academic achievement and the evaluation of learning environments based on students' views. Çırak (2016) performed a study to examine the effect of blended learning supported by the quantum learning design framework on student achievement, motivation, social-cognitive-teaching presence and perceptions and to determine the effective components of blended learning. The study was designed in a mixed way including both quantitative and qualitative research methods. Özdemir (2016) examined the effect of 6th grade students' academic achievement and the anxiety levels in mathematics and their attitude towards mathematic and technology about flipped classroom model prepared in blended learning.

In addition to these studies Şimşek (2016) was examined the effect of Computer Algebra Systems (CAS) on academic success, conceptual understanding, computational skills and problem-solving skills of definite integral teaching in blended learning environments. Dürnel (2018) in thesis study, examined the teaching process of fraction, decimal and percentage units of fifth grade math lesson in blended learning environment. The study was designed as a case study and data were collected by a mixed method. Face-to-face parts of the blended learning environment were transferred into practice in the classroom environment, and the online parts were performed in the Moodle Learning Management System.

Also Dursun (2018) investigated the effect of blended learning with social media supported learning on the students' mathematics achievements and self-efficacy perceptions in Mathematics

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Education. The research was carried out on “Square-Roots” which were found to constitute pre-cognitive knowledge of many mathematical topics in the following years and that students were challenged in the learning stage. Öner, Yıldırım and Bars (2017) investigated the effect of blended learning on students’ achievement for the topic of quadratic equation in mathematics education. Pesen and Oral (2016) presented the effect of blended learning approach on academic success and motivation of pre-service teachers. Ünsal (2012) performed a study to examine the impact of blended learning on effectiveness, student success, motivation, and retention. In the study blended learning (web-based learning and face-to-face learning) and face-to-face learning approach were used. Blended learning approach is to blend web-based teaching technology through education purpose. Yıldırım and Vural (2016) conducted to explore student opinions and effects on their perception of success of blended learning environment constituted as a combination of classroom training process and distance education procedures.

Ministry of National Education (MoNE) have taken actions related to the use of blended learning in schools especially since 2005. EBA (Educational Informatics Network) is an online social education platform where teachers and students can reach a plenty of contents related to their studies. The platform allows teachers to upload their teaching materials and presentations to the platform while they can also benefit from the other materials uploaded by other teachers. EBA acts as a huge archive of information for both teachers and students with its interactive/synchronous and noninteractive/unsynchronous learning options. EBA has also become the main online course platform of schools in the pandemic process where 1 million students can use online and attend classes at the same time. In the pandemic process, EBA TV plays an active role in teaching. So far, 674 teachers in 93 branches have participated in the video lessons and 2358 lesson videos and 221 activity videos have been prepared.

The ministry has initiated a project named “I have an idea for the distance education” and been collecting everyone’s opinions to improve the distance education and strengthen blended learning practices in Turkey. The opinions can be shared on the link http://uzaktanegitimebirfikrimvar.meb.gov.tr

In addition, MoNE regularly organises in-service training activities for teachers related to blended learning approach. Mostly blended learning in Latvia is fulfilled mixing face-to-face and online activities. For instance, a lot of teachers use MOODLE learning server (https://macibas.e-skola.lv/) to create tests, write theory etc. Similarly, teachers use digital learning tool Uzdevumi.lv (https://www.uzdevumi.lv), where teacher can use existing materials or create their own. Uzdevumi.lv is more student and parent friendly than MOODLE and more teachers choose it. Also, there is possibility to import students from electronically class journal (https://www.e-klase.lv/ etc.)

4.3. Flipped learning (theoretical knowledge)

Flipped learning is an instructional approach which basically 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 learning. 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, 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.

To enhance student learning in flipped classrooms, teachers should be flexible in terms of their expectations of students. Students should be given enough flexibility to complete the assignments and readings at their own pace. It does not mean that they are given infinite credit; yet, individual differences should be taken into account to address equity issues. Thus, flipped classrooms should re-define the classroom culture to maximize student learning. While in traditional learning settings the teacher is the one who owns the subject matter and share this precious information with the students, flipped learning requires that students are the ones who actively search for the necessary information and construct their knowledge base. Thus, teachers who flipped their classrooms should enhance the learning culture which is more student-centered and student-directed. This culture also nurtures student freedom and self-expression with a focus on evaluating their own learning (Arfstom, Hamden, McKnight, & McKnight, 2013).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Another important aspect of flipped classrooms is that while making instructional decisions the teacher should always keep in mind the overarching goal of flipped learning, assigning the right tasks for the right medium. The content that can be mastered through studying the online resources should not be assigned as a face-to-face task or vice versa. Most of they can master on their own should be assigned as an online task; however, tasks requiring collaboration, teacher assistance and scaffolding, problem solving and critical reflection are mostly suitable for face-to-face environments. The teacher intentionally design and implement the instructional tasks to promote both conceptual and procedural understanding. Additionally, the teacher always keep it in mind that flipped classrooms should be student-centered environments for active participation and enhanced student learning.

In flipped classrooms, the role of a professional educator is an essential component to fulfill the potential of flipped learning. Teachers are expected to observe and monitor student progress, provide continuous and sound feedback to students, and conduct necessary assessments. Professional educator always reflects on one's own practices, asks for feedback and continuously work to improve one's own teaching performance (https://flippedlearning.org/definition-of-flipped-learning/).

Flipped learning flips the way of traditional way of learning by bringing school work to home and homework activities into the classroom. This way, flipped learning approach allows teachers to practice different and various teaching methods and techniques in the classroom more comfortably since students learn the content at home through the use of technology.

Flipped learning has four pillars constructing the foundations of the approach that are flexible learning, learning culture, intentional content and professional educator. Teachers should allow students to choose where and when to study and provide a flexible schedule for learning activities while promoting students to reflect on their learning from time to time. The learning culture in flipped learning transforms into student-centred learning and allows students to learn from different resources other than teachers who are the main information sources of traditional teaching approaches. However, the content to be learned can be found in different forms and aspects on the Internet and teachers should decide which content they should provide students directly (intentional content) and which content the students can search on the Internet to expand their perspectives. While all these are happening, teachers should act more professionally during the in-classroom activities and facilitate learning process by helping students to manage the learning process with discussions, role-plays, hands-on activities, etc. This requires teachers to work harder and get tired more than usual.

In this new context, the phases of the lesson are also changing and one of the most popular methodologies for planning a lesson, both in presence and at a distance, is the 4Cs.

These letters represent four phases to be applied to the lesson:

Connect: In this phase it is important to develop explicit links between the subjects and the students' curiosities. This creates engagement and connection between the students, the teacher and the subject.

Construct: The second phase is based on learning by doing, i.e. the possibility of learning through reasoning, physical creation and manual work.

Contemplate: The construction phase is followed by a contemplation phase. In this precise moment, students are asked to observe what has been built in order to deepen and understand and develop new connections between previous knowledge and new topics.

Continuous: In the last phase there is a sharing of the work done with other students and the preparation of the next lessons thanks to a mechanism based on curiosity and stimulation. Learning is more fun and enjoyable if an appropriate challenge is maintained.

The classic set-up is a class where the teacher gives a frontal lecture explaining concepts to the students and answering questions. This is followed by a phase of private study by the students at home in which the knowledge acquired during the lesson is consolidated. Finally, the teacher checks the student's level of learning by means of a written or oral check on the knowledge acquired. In this case we talk about standard teaching.

Flipped teaching, on the other hand, was created in 2007 with the aim of enhancing teaching in difficult contexts. It has an upside-down approach in which, in the first phase in class, the teacher stimulates the students' curiosity, they then develop and produce materials in the second phase at home and finally present them to the class, sharing what they have learned with the rest of the

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

students. In this way, the student becomes directly responsible for his or her own learning and is stimulated by an engaging environment that works through the acquisition of skills and not through the transfer of knowledge. It also increases the degree of inclusion and sociability within the class group.

However, this does not mean eliminating the previous teaching methodologies but increasing the degree of authority of the teacher who does not merely transfer and evaluate content but guides the student in a process of elaboration and stimulates him to learn by expressing his own abilities.

The role of the student also changes and he/she will not limit him/herself to acquiring contents in a passive way but will have to cooperate and interact with the teacher and the class group in order to develop new skills through the experimentation of new activities. The intrinsic aim is to develop greater autonomy.

There are beliefs that flipped learning is about making video lessons and/or online lessons and giving them to students before onsite lecture; however flipped learning is about bringing the learning process outside the classroom (Waterworth, 2014). Unknowingly the teachers have been practicing flipped learning by sending home a passage of text to read, research something, asking to practice mathematical tasks etc. The most important aspect of flipped learning is to promote student self-regulation and self-regulated learning behaviors (Talberg, 2017). Without self-regulated learning students will not get on point during class.

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. 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.

As with the blended learning approach, shifting to flipped learning at first generates extra work for the teacher (Bowdon et.al, 2015) however it enables students to complete knowledge and understanding as they are ready to apply, analyze and evaluate gained knowledge during onsite activities (Waterworth, 2014).

4.4. Flipped learning practices in higher education institution

Flipped learning environments create excellent opportunities for instructors to use the face-to-face class time more effectively. While students spent their away time for studying the low level aspects of the subject matter such as knowledge and memorizing skills at home, they work through the hard core tasks at school under the instructor’s guidance. School time is devoted to group work that requires active student participation and interaction. Such learning environments allows the students to engage in high level thinking skills of Bloom’s taxonomy, including application, analysis, and evaluation (Bloom, 1956). Flipped learning is the opportunity for both the students and the teacher for differentiated instruction where the teacher finds the time to tailor the level of the task according to the pace of the students and monitor their progress closely without spending the class time on lecturing and explaining basics of the course material. Students are able to task their questions and receive high quality feedback from their peers as well as from the instructor. It is a distinguishing characteristic of flipped learning is that it is highly tailored for the needs of higher education. There are many rich online resources and published materials available for student to study and understand basic concepts of course materials without the presence of the instructor. Internet resources, including videos, podcasts and learning portals, can instantly be translated into the students’ native language so that students will have access to rich resources that they cannot learn from otherwise.

Higher education institutions traditionally rely on face-to-face lecture as the main teaching methodology; however, flipped learning seems to be a suitable approach for teaching students at tertiary level. Higher education students are mature enough to individually study the subject matter online. They can watch online videos; read and study lecture notes and understand basic elements of the subject matter without listening to their instructor at large lecture halls. The in-class time is devoted to small group discussions, problem solving, and listening to the instructor’s responses to questions and insight about the topic. This cycle of learning perfectly resembles features of flipped learning. Flipped classrooms are highly in favor of student engagement and contribution to the

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

learning process. This particular feature can be blended into higher education instructional settings. (https://flippedlearning.org/wp-content/uploads/2016/07/HigherEdWhitePaper-FINAL.pdf).

So far, several review studies have been conducted to show the impact of utilizing flipped classrooms in higher education; for example, there are review studies in nursing education (Betihavas et al., 2016; Tan et al., 2017), medical education (Chen et al., 2017) and engineering education (Karabulut Ilgu et al, 2018). Besides review studies, recent research studies have been conducted to examine the effect of flipped classrooms in higher education students' learning and self-regulation (Kuzminska, Morze, & Smyrnova-Trybulska, 2017; Sezer, 2017; Sun, Wu & Lee, 2017).

The flipped classroom model, which was introduced by chemistry teachers Bergmann and Sams in 2007 so that students do not fall behind due to participating in various activities, expresses a learning environment in which the teaching in the classroom and the practices performed outside the classroom are replaced. This model is an approach based on learning the theoretical knowledge that students need to learn at home with the help of videos and other teaching materials, and doing their homework at school, in contrast to the usual "Teaching at School Homework" system (Zownorega, 2013). When the studies in this field are examined, most of them question whether the inverted classroom model actually increases academic success in education. However, various variables such as students' attitude towards this model, perception, permanence, critical thinking, motivation, satisfaction and examination of student views were examined through various branches through both quantitative, qualitative and mixed methods. While some of the studies have yielded common results, there have been studies showing different (opposite) results. For this reason, the inverted-face class model whose effect is examined in terms of various variables does not have a certain result (Güç, 2017). As a result of the researches, it was seen that the flipped learning model was mostly applied at the secondary school level in the master's and doctoral theses and article studies.

Güç (2017) analyzed the effect of the flipped classroom model on the students' academic achievements in and attitudes towards the 7th grade mathematics courses, against the background of the "Rational Numbers and Operations with Rational Numbers" topic. Tekin (2018) aimed to examine the effect of flipped classroom model on 10th grade students' achievement on Polygons and Quadrilaterals and attitudes towards mathematics. In addition, the views of the practicer teacher, the teacher in video content and the students in experimental group on flipped classroom model have been examined. Çevikbaş (2018) investigated student engagement in a math classroom based on flipped classroom practices. Within the scope of this purpose, the role of flipped classroom model in the behavioral, emotional and cognitive dimensions of student engagement were investigated. Moreover, the flipped classroom practices having an important role in student engagement were examined, and the participants' opinions on how the flipped classroom practices can be improved were received. Bolatlı (2018) examined flipped classroom learning environment supported by mobile application was prepared and the students' opinions about cooperative learning were evaluated along with their effect on academic achievement. Deniz (2019) determined the effect of game and activity supported flipped class model on student achievement, persistence, problem solving ability and reflective thinking ability towards problem solving in mathematics lesson and to determine student views about application. In the research, exploratory sequential design, one of the mixed method designs, where quantitative and qualitative data were used together, was used. Bulut (2019) aimed to investigate the effect of Flipped Classroom Model on lower and higher level learning of students according to Revised Bloom Taxonomy on 7th grade "ratio-proportion" and determine student views about the model. Action research method was used in this research. Özdemir (2019) performed a study to examine the effect of using Flipped Classroom in geometry teaching on pre-service mathematics teachers' attitudes towards geometry. The quantitative sample of the study was consisted of 79 students using the appropriate sampling from Bayburt University Faculty of Education Elementary Mathematics Teacher Education Program in 2018-2019 Academic Year Fall Semester. Kalafat (2019) researched the effect of "Flipped Classroom" teaching model on the mathematical achievement of students, which includes technological components and supports constructivist approach applications. The implementation period of the research was included "Algebraic Expressions and Equations" subjects. Akdeniz (2019) investigated the effect of flipped class model on students' academic success, attitudes and retention. Traditional education model is employed in control group while flipped class model is employed in treatment group. This study is spread over ten weeks and employed a hybrid model in which both qualitative and quantitative data is utilized. Aydın (2020) revealed to teach the subject of operation with integer numbers to 7th grade students by using the method of flipped classroom model. During the study, the effect of this model to the academic

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

achievement is analyzed and it is aimed to present the ideas about this model in details. The Classroom Engagement Inventory was used as a data collection tool in the study by Kaya (2018), which was conducted to investigate the effect of inverted learning model on classroom participation in mathematics teaching of middle school students. Özdemir, Aydın, and Demir (2020) aimed to investigate the effect of using flipped classroom applications in geometry teaching on the attitudes of pre-service mathematics teachers towards geometry.

Flipped learning has become one of the blended learning applications used in higher education in Turkey. There are different research activities showing the pros and cons of the application of flipped learning at the higher education level in our country.

According to the research findings, positive contributions and advantages of the flipped learning are being ready before the lesson, possibility to become more active in the classroom, time for more repetition, more engagement in the content, having more fun, providing permanent learning, in-depth learning, preventing distraction. Negative aspects and disadvantages of the flipped learning are lack of technology tools, taking too much time to work at home, while watching videos at home not being able to interact with the teacher and ask questions immediately, needing a long process to get used to the application, and feeling lonely during the learning process at home (Turan & Göktaş, 2015; Evin-Gencel, 2020).

In the University of Latvia as well as other higher education institutions a tendency to use flipped learning practices can be observed. Mostly professors are giving students paragraphs to read without any instructions and this usually leads to the defeat. As mentioned above, the most important thing is to give some instructions, some guidelines so students do not get lost during the reading-learning process. For instance, the professor can give the same paragraph to read and mention that there are some mistakes in it, most students will read this paragraph and try to find that mistake. Of course, most will not find mistakes; nevertheless it is a great start for a discussion in the following lecture. Students will want to come to the lecture to tell about mistakes they found or to find out where the mistakes were even if there were none.

However, there are also some good examples. In the University of Latvia before the physics lab session student must read and research theory about laboratory work and physics in it. Also, student must complete online test with at least 80% correct answers. During the practical assignment student can ask for some help. After practical assessment is completed and report is written, student and professor have a dialog about the laboratory work. During the discussion report is broken into steps and every is discussed as well as the problems occurred, theory issues and many other aspects. As a result, students tend to have more complete knowledge about theory that is learned through laboratory works and discussions than by attending *classic* lectures.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

5. RECOMMENDATIONS

5.1. Recommendations for "how robots can be used in primary school mathematics education through blended learning approach"

Teachers use many kinds of instructional materials as tools to foster students' understanding of subject matter. Nature of instructional tools change by the subject matter and the available technologies. For example, fifty years ago it was not expected of teachers using computers or smart boards to facilitate student learning; but, nowadays teachers integrate hundreds of technologies into their teaching for a better teaching. Like many other mediums, use of robots is a relatively recent phenomena in teaching K-12 subject matter. They are mainly used to teach programming, electronics and basics of mechanics. Use of robots in K-12 classrooms can be highly motivating for students.

There are various kinds of robots for teaching primary school students such as Dash&Dot®, Lego Wedo®, Blue-Bot® and Cubetto®. Such robots are operated through a block-based language (Bellas, Salgado, Blanco, & Duro, 2019). It is claimed that block-based coding is a sound way of introducing basic programming skills to primary school children. They are also advocated for their role in increasing student motivation and participation. It is introduced as useful tools which help students entertain as they are learning the subject matter. Additionally, it makes the content more interesting and engaging for primary students. Robotic environments are open to activities involving different kind of games which help raise student motivation. Individuals can program the robots as they want it, so, each individual has a personal input and gain from robots' integration into educational environments.

Teachers can use educational robots to introduce authentic problems to students. Such problems require students to use high level thinking and develop original solutions. Active participation and engagement occur while working through authentic tasks. Such problems demand integration of STEM disciplines for an effective solution. Thus, use of robots allows students engage in problem solving tasks that need using basic programming skills to move the robots. Such problem solving settings are built on collaborative efforts of all students. They interact with each other to generate the most optimum solution. Through such integrations, they agree or disagree with other. They negotiate to come to an agreement for a better solution. As a result, use of robots in education settings play a key role to enhance students both cognitively and socially (Stergiopoulou, Karatrantou, & Panagiotakopoulos, 2017).

5.2. Suggestions to "how robots can be used in primary school mathematics education through blended learning approach"

In the future work, it is important to identify the factors hindering the development of blended learning to increase technical literacy among larger groups of children. Other educators are working in this field as well. While using construction or robotic kits in education has its place in the educational system it is important to find the means of quicker renewal of those Technologies they utilize to cope with and fully exploit the increased speed of communication available today (Yudin, Vlasov, Salmina & Shalashova, 2020).

Research findings identified four themes that influenced student engagement with the online robotics course: Access to the online course, the students' background knowledge and skills, the students' interaction with the online course and the students' conation or internal motivation. The research findings are discussed in terms of areas that need to be addressed when using an online course to teach robotics. These areas are the course design, student considerations and course implementation. Course design, or how the course is structured, includes opportunities for students to develop their thinking skills, experiences and activities for learning, and opportunities for conversation and interaction. Student considerations focus on the needs of the learners and their readiness to ensure successful engagement in the online course in terms of their background knowledge and skills in electronics and Web 2.0 tools, their conation and their key competencies. Course implementation includes the factors that need to be taken into account in the execution of the online course such as reliable access to the online course, the students' interactions with the online course, and the learning culture of the school and classroom, and the role of the teacher. In the future, more attention should be paid on developing different learning activities or learning mechanisms to improve students' control belief in learning robotics to improve their leaning strategies (Lin & Liu, 2011).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

REFERENCES

Akdeniz, E. (2019). Ters yüz sınıf modelinin akademik başarı, tutum ve kalıcılık üzerine etkisi. Yayımlanmamış yüksek lisans tezi, Necmettin Erbakan Üniversitesi, Konya.

Akkuş, S. (2009). Diferansiyel denklemlerin sayısal çözümlerinde Adomian ayrışım metodu ve Homotopi perturbasyon metodu'nun karşılaştırılması. Yayımlanmamış yüksek lisans tezi, Kahramanmaraş Sütçü İmam Üniversitesi, Kahramanmaraş.

Akman-Selçuk N. (2019). Eğitsel robotik uygulamalarının ortaokul öğrencilerinin ders motivasyonları, robotik tutumları ve başarıları açısından incelenmesi. Yayınlanmamış doktora tezi, İstanbul Üniversitesi, İstanbul.

Aktepe, V., & Bulut, A. (2015). The impact of creative drama supported mathematics teaching on student accomplishment. *Kastamonu Eğitim Dergisi, 23*(3), 1081-1090.

Alkan, V. (2010). Matematikten nefret ediyorum! *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 28*, 189-199.

Alkan, V. (2011). Etkili matematik öğretiminin gerçekleştirilmesindeki engellerden biri: Kaygı ve nedenleri. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, *29*(29), 89-107.

Alkan, G. (2019). Matematik kaygısının nedenleri ve öğretmenin cinsiyetinin bu durum üzerindeki etkisi Yayınlanmamış yüksek lisans tezi, Van Yüzüncü Yıl Üniversitesi, Van.

Allan B. (2007). *Blended learning: Tools for teaching and training*. Facet Publishing.

Alpay, N. (2004). *Neden kaygılanıyoruz? Nasıl başa çıkabiliriz?* İstanbul: UKM Yayınları.

Amante, L., Quintas-Mendes, A., Monteiro, M., Miranda-Pinto, M., Osório, A., & Araújo, C. L. (2019). Computational thinking, programming and robotics in basic education: Evaluation of a in-service teachers' training B-Learning experience. In L. Gómez Chova, D. López Martínez, & I. Candel Torres (Eds.), ICERI 2019: *12th International conference of education, research and innovation: Conference proceedings* (pp. 10698–10705). International Association of Technology Education and Development.

Anwar, S., Bascou, N. A., Menekse, M., & Kardgar, A. (2019). A systematic review of studies on educational robotics. *Journal of Pre-College Engineering Education Research (J-PEER), 9*(2), Article 2. https://doi.org/10.7771/2157-9288.1223

Arfstom, K., Hamden, N., McKnight, K., & McKnight, P. (2013). A review of flipped learning. Retrieved from https://flippedlearning.org/wp-content/uploads/2016/07/LitReview_FlippedLearning.pdf

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*, 181-185.

Ashcraft M. H., Krause J.A.(2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review, 14*, 243-248.

Atmatzidou S., & Demetriadis S. (2016) Advancing students' computational thinking skills through educational robotics: A study on age and gender relevant differences. *Robotics and Autonomous Systems. 75*, 661-670.

Avcı, B., & Şahin, F. (2019). The effect of Lego Mindstorm projects on problem solving skills and scientific creativity of teacher candidate. *Journal of Human Sciences, 16*(1), 216-230.

Aydın, B. (2011). A study on secondary school students' mathematics anxiety in terms of gender factor. *Kastamonu Education Journal, 19*(3), 1029-1036.

Aydın, E., Delice, A., Dilmaç, B., & Ertekin, E. (2009). İlköğretim matematik öğretmen adaylarının matematik kaygı düzeylerine cinsiyet, sınıf ve kurum değişkenlerinin etkileri. *İlköğretim Online, 8*(1), 231-242.

Aydın, H. (2020). Ters-yüz edilmiş sınıf modelinin tam sayılarda işlemler konusunun öğreniminde akademik başarıya etkisi. Yayımlanmamış yüksek lisans tezi, Atatürk Üniversitesi, Erzurum.

Baloğlu, M. (2001). Matematik korkusunu yenmek. Kuram ve Uygulamada Eğitim Bilimleri Dergisi, 1(1), 59-76.

Baloğlu, M., & Koçak, R. (2006). A multivariate investigation of the differences in mathematics anxiety. *Personality and Individual Differences, 40*, 1325–1335.

Barak, M., & Assal, M. (2018). Robotics and STEM learning: Students' achievements in assignments according to the P3 task taxonomy-practice, problem solving, and projects. *International Journal of Technology and Design Education, 28*(1), 121-144. doi: 10.1007/s10798-016-9385-9

Barker, B. S., & Ansorge, J. (2007). Robotics as means to increase achievement scores in an informal learning environment. *Journal of Research on Technology in Education, 39*(3), 229–243.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Bascou, N. A., & Menekse, M. (2016, June). Robotics in K-12 formal and informal learning environments: A review of literature. In 2016 ASEE Annual Conference & Exposition.

Baydar, S. C., & Bulut, S. (2002). Öğretmenlerin matematiğin doğası ve öğretimi ile ilgili inançlarının matematik eğitimindeki önemi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 23*, 62-66.

Baykul, Y., (2002). *İlköğretimde matematik öğretimi.* Ankara: PegemA Yayıncılık.

Baylan, F. N. (2020). 2000-2017 Yılları arasında matematik kaygısı ile ilgili türkiye'de yapılan çalışmaların bazı değişkenlere göre incelenmesi. Yayınlanmamış yüksek lisans tezi, Selçuk Üniversitesi, Konya.

Beecher, K. (2017) *Computational thinking A beginner's guide to problem-solving and programming*. BCS Learning & Development.

Beisser, S. R. (2005). An examination of gender differences in elementary constructionist classrooms using Lego/Logo instruction. *Computers in the Schools, 22*(3/4), 7-19.

Beilock, S., & Willingham, D. T. (2014). Math anxiety: Can Teachers Help Students Reduce It? Ask the Cognitive Scientist. *American Educator, 38*(2), 28-32.

Bellas, F., Salgado, M. Blanco, T. F., & Duro R. J. (2019). Robotics in primary school: A realistic mathematics approach. Smart Learning with Educational Robotics Using Robots to Scaffold Learning Outcomes.

Benitti F.B.V., & Spolaôr N. (2017) How have robots supported STEM teaching?. In: Khine M. (eds) *Robotics in STEM education*. Springer, Cham. https://doi.org/10.1007/978-3-319-57786-9_5

Bers M. U., Flannery L., & Kazakoff E. R., & Sullivan A. (2014) Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education, 72*, 145-157.

Betihavas, V., Bridgman, H., Kornhaber, R., & Cross, M. (2016). The evidence for 'fipping out': A systematic review of the fipped classroom in nursing education. *Nurse Education Today, 38*, 15-21.

Bocconi, S., Chioccariello, Dettori, G., Ferrari, A., & Engelhardt, K. (2016). Developing computational thinking in compulsory education: Implications for policy and practice Luxembourg: Publications Office of the Eu-ropean Union. EUR 28295 EM

Bolatlı, Z. (2018). Mobil uygulama ile desteklenmiş ters-yüz öğretim ortamı kullanan öğrencilerin akademik başarılarının ve işbirlikli öğrenmeye yönelik görüşlerin incelenmesi. Yayımlanmamış yüksek lisans tezi, Selçuk Üniversitesi, Konya.

Bowdon M. A., Mansfield L. P., & Waldrop J. B. (2015) Conclusion: Reflecting on the flipping experience. *Best Practices for Flipping the College Classroom*, 146-155.

Bulut, R. (2019). Oran-orantı konusunun öğretiminde ters yüz sınıf modelinin etkisinin incelenmesi. Yayımlanmamış yüksek lisans tezi, Erzincan Binali Yıldırım Üniversitesi, Erzincan.

Boz, İ. (2018). The effect of teaching by game to academic success in primary school 4th class mathematics. *Uluslararası Ders Kitapları ve Eğitim Materyalleri Dergisi, 1*(1), 27-45.

Bloom, B. S. (Ed.). (1956). *Taxonomy of educational objectives, handbook I: Cognitive domain*. New York, NY: David McKay.

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and pre-service elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-179.

Cankoy, O., & Darbaz, S. (2010). Effect of a problem posing based problem solving instruction on understanding problem. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi (H. U. Journal of Education) 38, 11-24.

Carmo, J., & Ferraz, A. C. T. (2012). Ansiedade relacionada à matemática e diferenças de gênero: uma análise da literatura. *Psicologia da Educação*, 35, 53-71.

Ceylan, V. K. (2015). Harmanlanmış öğrenme yönteminin akademik başarıya etkisi. Yayımlanmamış yüksek lisans tezi, Adnan Menderes Üniversitesi, Manisa.

Chalmers C. (2018) Robotics and computational thinking in primary school. *International Journal of Child-Computer Interaction. 17*, 93-100.

Chaudhary, V., Agrawal, V., Sureka, P., & Sureka, A. (2016, December). An experience report on teaching programming and computational thinking to elementary level children using lego robotics education kit. In *IEEE eighth international conference on technology for education* (T4E) (pp. 38-41). Mumbai. doi: 10.1109/T4E.2016.15

Chen, N. S., Quadir, B., & Teng, D. C. E. (2011). A novel approach of learning English with robot for elementary school students. In Edutainment (p. 309-316).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Chélinho, J. (2019). Competencialização colabor@tiva em Educação de Infância com suporte numa plataforma supervisiva online. Doctoral thesis in education, University of Aveiro.

Ching, Y. H., Yang, D., Wang, S., Baek, Y., Swanson, S., & Chittoori, B. (2019). Elementary school student development of STEM attitudes and perceived learning in a STEM integrated robotics curriculum. *TechTrends, 63*(5), 590-601. doi: 10.1007/s11528-019-00388-0

Chung, C. C., Cartwright, C., & Cole, M. (2014). Assessing the impact of an autonomous robotics competition for STEM education. *Journal of STEM Education: Innovations and Research, 15*(2), 24-35.

Costa, M. J. (Ed.). (2019). CNaPPES 2018 – Congresso Nacional de Práticas Pedagógicas no Ensino Superior. Universidade do Minho.

Costelha, H., & Neves, C. (2018, April). Technical database on robotics-based educational platforms for K-12 students. In *IEEE international conference on autonomous robot systems and* Competitions (ICARSC) (pp. 167-172), Torres Vedras. doi: 10.1109/ICARSC.2018.8374178.

Cruz, C. (2013). A Educação para o Desenvolvimento Sustentável na formação de professores. A Web 2.0 e as interações numa Comunidade de Prática online, Doctoral thesis in multimedia in education, University of Aveiro.

Çevikbaş, M. (2018). Ters-yüz sınıf modeli uygulamalarına dayalı bir matematik sınıfındaki öğrenci katılım sürecinin incelenmesi. Yayımlanmamış doktora tezi. Gazi Üniversitesi, Ankara.

Çırak, S. (2016). Kuantum öğrenme döngüsü ile desteklenen harmanlanmış öğrenmenin etkililiği üzerine bir araştırma. Yayımlanmamış doktora tezi, Gaziantep Üniversitesi, Gaziantep.

Daniela L., & Strods R. (2019a) Educational Robotics for Reducing Early School Leaving from the Perspective of Sustainable Education. In: Daniela L. (eds) *Smart learning with educational robotics*. Springer, Cham. https://doi.org/10.1007/978-3-030-19913-5_2 .

Daniela L., & Strods R. (2019b) Educational Robotics for Reducing Early School Leaving from the Perspective of Sustainable Education. *Smart Learning with Educational Robotics*, 43-61.

Davarcıoğlu, P. (2008). Orta öğretim dokuzuncu sınıf öğrencilerinin matematik korkusu. Yayınlanmamış yüksek lisans tezi, Abant İzzet Baysal Üniversitesi, Bolu.

Delioğlu, H. N. (2017). Sekizinci sınıf öğrencilerinin matematik başarısı ile sınav ve matematik kaygısı, matematiğe yönelik öz-yeterlik algısı arasındaki ilişki. Yayımlanmamış yüksek lisans tezi, Adnan Menderes Üniversitesi, Aydın.

Demir, S., & Durmaz, M. (2018). İlköğretim matematik öğretmenlerinin matematik kaygısı hakkındaki görüşleri ve müdahale yöntemleri. *Academia Eğitim Araştırmaları Dergisi*, *3*(1).

Deniz, L., & Üldaş, İ. (2008). Öğretmen ve öğretmen adaylarına yönelik matematik kaygı ölçeğinin geçerlilik güvenilirlik çalışması. *Eğitim Araştırmaları Dergisi, 7*(2), 49- 62.

Dowker, A., Sarkar A., & Chung Yen Looi C. Y. (2016) Mathematics anxiety: What have we learned in 60 years? *Front Psychol, 7*, 508. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4842756/

Dursun, C. (2018). Sosyal medya destekli harmanlanmış öğrenme yönteminin öğrencilerin matematik başarılarına ve öz-yeterlik algılarına etkisinin incelenmesi. Yayımlanmamış yüksek lisans tezi, Marmara Üniversitesi, İstanbul.

Dürnel A. (2018). 5. sınıf matematik dersinin harmanlanmış öğrenme ortamında işlenmesi: Bir durum çalışması. Yayımlanmamış yüksek lisans tezi, Bahçeşehir Üniversitesi, İstanbul.

Elkin, M., Sullivan, A., & Bers, M. U. (2016). Programming with the KIBO robotics kit in preschool classrooms. *Computers in the Schools, 33*(3), 169-186.

Ergenç, T. S. (2011). İlköğretim yedinci sınıf öğrencilerinin matematik dersi bölgesel hazır bulunuşluk düzeyleri ile matematik kaygı düzeyleri arasındaki ilişkinin incelenmesi, Yayımlanmamış yüksek lisans tezi, Eskişehir Osmangazi Üniversitesi, Eskişehir.

Ertem-Akbaş, E. (2018). Öğretmenlerin bakış açısıyla ilkokulla başlayan matematik korkusunun nedenlerinin ve çözüm önerilerinin incelenmesi. *International e-Journal of Educational Studies (IEJES), 2*(3), 12-25.

Evin-Gencel, İ. (2020). A phenomenological study of graduate students' experiences on flipped learning in curriculum development course. *International Journal of Educational Studies and Policy,1*(1), 1-14.

Faust, M.W., Ashcraft, M. & Fleck, D.E. (1996).Mathematics anxiety effects in simple and complex addition. *Mathematical Cognition, 2*, 25–62.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Felicia, A., & Sharif, S. (2014). A review on educational robotics as assistive tools for learning mathematics and science. *Int. J. Comput. Sci. Trends Technol, 2*(2), 62-84.

France I., & Bertule D. (2019) STEM masterminds – an advanced level integrated stem curriculum. ICERI2019 Proceedings, 7220-7226.

Freitas, D. (2015). Blended learning na formação contínua em educação sexual: Um estudo com educadores de infância e professores do 1.o CEB, Doctoral thesis in education, University of Lisbon.

GAVE/Ministério da Educação (2018). Resultados nacionais das provas de aferição, 2018. Consultado em dezembro de 2020, http://iave.pt/images/FicheirosPDF/Docs_Avalia%C3%A7%C3%A3o_Alunos/Relat%C3%B3rios/Informacao_Resultados_PA2018_16jan.pdf

Gomes, C. A., Novais, A., & Abrantes, I. (2016). Exploring the vineyard cycle: Mobile technology in non-formal environmental education settings. 2016 *international symposium on computers in education*, SIIE 2016: Learning Analytics Technologies. https://doi.org/10.1109/SIIE.2016.7751850

Gomes, C.A., Gomes, H. Rego, B., Sousa, B., Loureiro, M & Rocha, P. (2019). Smart city kids lab: creative computing in primary school. International Symposium on Computers in Education (SIIE), Tomar, Portugal, pp. 1-6, doi: 10.1109/SIIE48397.2019.8970130.

Gonçalves, B. M., & Osório, A. (2018). Massive Open Online Courses (MOOC) to improve teachers' professional development. *RE@D - Revista de Educação a Distância e Elearning, 1*(1), 52.

Gough, M. F. (1954). Why failures in mathematics? Mathemaphobia: Causes and treatments. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 28*(5), 290-294.

Grover, S., & Pea, R. (2013). Computational thinking in K–12: A review of the state of the field. *Educational researcher, 42*(1), 38-43.

Gutiérrez-Pérez B. M., & Martín-García A. V. (2020) Evaluation of Quality in Blended Learning Training. Blended Learning: Convergence between Technology and Pedagogy. Volume 126 of Lecture Notes in Networks and Systems. Pages 91-113.

Gündüz-Çetin, İ. (2020). Ortaöğretim öğrencilerinin matematik umutsuzluğunu yordayan değişkenler: matematik kaygısı, matematiğe yönelik motivasyonel inançlar, matematik başarısı (Köşk ilçesi örneği). Yayınlanmamış yüksek lisans tezi, Adnan Menderes Üniversitesi, Aydın.

Hannula, M. S. (2006). Affect in mathematical thinking and learning: Towards integration of emotion, motivation, and cognition. In New Mathematics Education Research and Practice, Brill-Over three centuries of scholary publishing. https://brill.com/view/book/edcoll/9789087903510

Helmane, I. (2006). Sākumskolēnu matemātisko prasmju apguves un emociju mijsakarība [Correlation of pupils emotions and math skills acquisition in Mathematics in the primary school], PHD paper; available at: http://dspace.lu.lv/dspace/handle/7/24/browse?value=Helmane+%28Balode%29%2C+Ineta&type=author (in Latvian)

Helmane, I. (2011). Aspects of thematic choice within the mathematics based on thematic approach in primary school. *Proceedings of the international scientifical conference* (pp. 169-177), Rezekne: Rezeknes Academy

Hembree R. (1990). The nature, effects, and relief of mathematics anxiety. journal for research in mathematics education. https://www.jstor.org/stable/749455?read-now=1&seq=2#page_scan_tab_contents

Highfield, K. (2010). Robotic toys as a catalyst for mathematical problem solving. *Australian Primary Mathematics Classroom, 15*(2), 22-27.

Hlalele, D. (2012). Exploring rural high school learners' experience of mathematics anxiety in academic settings. *South African Journal of Education, 32*(3), 267-278.

Hofmann J. (2011). *Blended learning*. American Society for Training and Development.

Hussain, S., Lindh, J., & Shukur, G. (2006). The effect of LEGO training on pupils' school performance in mathematics, problem solving ability and attitude: Swedish data. *Educational Technology & Society, 9*(3), 182-194.

Irvine, V., Code, J., & Richards, L. (2013). Realigning higher education for the 21st-century learner through multi-access learning. *MERLOT Journal of Online Learning Teaching, 9*(2), 172–186.

Jackson, C. D. & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *The Mathematics Teacher, 92*(7), 583-586.

Jonassen, D. H. (2000). *Computers as mindtools for schools*. NJ: Prentice Hall.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Kahn Jr, P. H., Kanda, T., Ishiguro, H., Freier, N. G., Severson, R. L., Gill, B. T., & Shen, S. (2012). Robovie, you'll have to go into the closet now: Children's social and moral relationships with a humanoid robot. *Developmental psychology, 48*(2), 303.

Kalafat, H. Z. (2019). Ters yüz sınıf modeli ile tasarlanan matematik dersinin 7. sınıf öğrencilerinin akademik başarısı üzerine etkisinin incelenmesi. Yayımlanmamış yüksek lisans tezi, Marmara Üniversitesi, İstanbul.

Kalelioğlu, F., Gülbahar, Y., & Doğan, D. (2018). Teaching how to think like a programmer: Emerging insights. In H. Özçınar, G. Wong ve H.T. Öztürk (Ed.), *Teaching computational thinking in primary education* (pp. 18-35). Hershey, PA: IGI Global Publishing.

Kapa, E. (1999). Problem solving, planning ability and sharing processes with LOGO. *Journal of Computer Assisted Learning, 15*, 73-84.

Karaahmetoğlu, K. (2019). Proje tabanlı Arduino eğitsel robot uygulamalarının öğrencilerin bilgisayarca düşünme becerileri ve temel STEM beceri düzeyleri algılarına etkisi. Yayınlanmamış yüksek lisans tezi, Amasya Üniversitesi, Amasya.

Karabulut-Ilgu, A., Jaramillo Cherrez, N., & Jahren, C. T. (2018). A systematic review of research on the fipped learning method in engineering education. *British Journal of Educational Technology, 49*(3), 398-411.

Kaya, D. (2018). The effect of flipped learning model on middle school students' classroom engagement in teaching mathematics. *Sakarya University Journal of Education. 8*(4).

Kazelskis, R., Reeves, C., Kersh, M., Bailey, G., Cole, K., Larmon, M., & Holliday, D. (2000). Mathematics anxiety and test anxiety: Separate constructs? *The Journal of Experimental Education, 68*(2), 137-146.

Kazez, H., & Genç, Z. (2016). İlkokul Matematik Öğretiminde Yeni Bir Yaklaşım: Lego MoretoMath. *Journal of Instructional Technologies & Teacher Education, 5*(2), 59-71.

Keçeci, T. (2011). Matematik kaygısı ve korkusu ile mücadele yolları. *2nd International conference on new trends in education and their implications* (pp. 55-67), 27-29 April, 2011 Antalya-Turkey.

Khanlari, A., & Mansourkiaie, F. (2015, July). Using robotics for STEM education in primary/elementary schools: Teachers' perceptions. In *10th international conference on computer science & education (ICCSE*) (pp. 3-7). IEEE.

Koç Deniz, H. (2019). Matematik dersinde oyun ve etkinlik destekli ters yüz sınıf modelinin öğrenci başarısına, problem çözme ve problem çözmeye yönelik yansıtıcı düşünme becerilerine etkisi. Yayımlanmamış doktora tezi, Fırat Üniversitesi, Elazığ.

Kopcha, T. J., McGregor, J., Shin, S., Qian, Y., Choi, J., Hill, R., ... & Choi, I. (2017). Developing an integrative STEM curriculum for robotics education through educational design research. *Journal of Formative Design in Learning, 1*(1), 31-44.

Korkmaz, O., Altun, H., Usta, E., & Özkaya, A. (2014). The effect of activities in robotic applications on students' perception on the nature of science and students' metaphors related to the concept of robot. *International Journal on New Trends İn Education and Their Implications, 5*(2).

Kozima, H., & Nakagawa, C. (2007, August). A robot in a playroom with preschool children: Longitudinal field practice. In Robot and Human interactive Communication, 2007. RO-MAN 2007. The 16th IEEE international symposium on (pp. 1058-1059).

Kutluca, T., Alpay, F. N., & Kutluca, S. (2015). An investigation of factors affecting 8th grade math students' anxiety levels. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 25*, 202-214.

Kuzminska, O., Morze, N. & Smyrnova-Trybulska, E. (2017). Flipped learning model: Tools and experience of its implementation in higher education. doi: 10.15804/tner.2017.49.3.15

Laurillard, D. (2015). Thinking about blended learning: A paper for the thinkers in residence programme. In G. Van der Perre & J. V. Campenhout (Eds.), *Higher education for the digital era: A thinking exercise in Flanders* (pp. 7–33). KVAB.

Lazarus, M. (1974). Mathephobia: Some personal speculations. *National Elementary Principal, 53*, 16-22.

Lee E., Kafai Y. B., Vasudevan V., & Davis R. L. (2014). Playing in the arcade: Designing tangible interfaces with MaKey MaKey for scratch games. In Nijholt A. (ed.), *Playful user interfaces* (pp. 277-292). Springer, Singapore.

Lin, C. H. & Liu, E. Z. (2011). A pilot study of taiwan elementary school students learning motivation and strategies in robotics learning. Conference: Edutainment Technologies. Educational Games and Virtual

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Reality/Augmented Reality Applications - 6th International Conference on E-learning and Games, Edutainment Proceedings.

Loureiro, A. (2019). Pedagogical Use of ICT - Strengthening Teacher Skills in a B-Learning Master's Program. Proceedings of the 2019 International Symposium on Computers in Education (SIIE), 1–5.

Loureiro, A., Cardona, M. J., & Rocha, D. (Eds.). (2020). CNaPPES 2019 – Congresso Nacional de Práticas Pedagógicas no Ensino Superior. Escola Superior de Educação de Santarém.

Lyons. I.M., & Beilock, S.L. (2011). Mathematics anxiety: Separating the math from the anxiety. October 2011 Cerebral Cortex 22(9):2102-10

Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: A longitudinal panel analysis. *Journal of Adolescence, 27*, 165-179. doi: 10.1016/j.adolescence.2003.11.003

Mataric, M. J., Koenig, N., & Feil-Seifer, D. (2007). Materials for enabling hands-on robotics and STEM education. AAAI spring symposium on robots and robot venues: Resources for AI education.

Matemātika 1.–9. klasei. Mācību priekšmeta programmas paraugs [Mathematics 1-9 grade. Mathematics curricula]. (2019). Valsts izglītības satura centrs, Skola2030. Retrieved from https://mape.skola2030.lv/resources/159 (in Latvian)

Matemātika 1. – 9. klasei [Mathematics 1-9 grade]. (2005). Valsts izglītības satura centrs. Retrieved from file:///C:/Users/User/AppData/Local/Temp/matematika_1_9.pdf (in Latvian)

Mattar Neto, J., Ramos, D., & Loureiro, A. (2019). Recursos Digitais em Educação: Estudo de caso de um mestrado blended em Portugal. In Associação Brasileira de Educação a Distância (Ed.), Atas do 25.o CIAED Congresso Internacional ABED de Educação a Distância (pp. 1–10). Associação Brasileira de Educação a Distância - ABED.

Mendes, A. C., & Carmo, J. D. S. (2014). Atribuições Dadas à Matemática e Ansiedade ante a Matemática: o relato de alguns estudantes do ensino fundamental. *Bolema: Boletim de Educação Matemática, 28*(50), 1368-1385.

Menezes, L., & Costa, A. M. (2020). Writing to learn mathematics. In L. Gómez Chova, A. López Martínez, I. Candel, & Torres (Eds.). Proceedings of ICERI2020 Conference (pp. 841-848). Seville: IATED.

Menezes, L., Fernandes, A., Viseu, F., Ribeiro, A., & Flores, P. (2020). Perspetivas de professores de Matemática sobre o humor e o seu valor educacional. *Bolema, 34*(66), 332-353.

Menezes, L., Gomes, H., Ribeiro, A., Martins, A. P., Flores, P., Viseu, F., Oliveira, A., Matos, I. A., Balula, J. P., & Delplancq, V. (2019). Humor in mathematics teaching: tasks for the classroom (2nd edition, revised edition). Viseu: Litoprint and Higher School of Education of Viseu.

Merdan, M., Lepuschitz, W., Koppensteiner, G., & Balogh, R. (Eds.). (2016). *Robotics in education: Research and practices for robotics in STEM education* (Vol. 457). Springer.

Ministério da Educação (2020), Clubes de programação e Robótica, https://www.erte.dge.mec.pt/clubes-de-programacao-e-robotica

Ministry of National Education [MoNE](2018). Matematik dersi öğretim programı (ilkokul ve ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. sınıflar). Ankara: Talim ve Terbiye Kurulu Başkanlığı.

Mitnik, R., Nussbaum, M., & Soto, A. (2008). An autonomous educational mobile robot mediator. *Autonomous Robots, 25*(4), 367–382.

Morgan, C. T. (2019). *Psikolojiye giriş*, (Çev. S. Karakaş ve R. Eski), 23. Baskı, Eğitim Yayınevi.

Noteikumi par valsts pamatizglītības standartu un pamatizglītības programmu paraugiem (2018) [Regulations of State Basic Education Curricula and Primary Education Programmes]; MK noteikumi Nr. 747, IV nodaļa, 7. punkts, 7.4. apakšpunkts; available: https://likumi.lv/ta/id/303768-noteikumi-par-valsts-pamatizglitibas-standartu-un-pamatizglitibas-programmu-paraugiem(in Latvian) .

Nugent, G., Barker, B., & Grandgenett, N. (2008). The effect of 4-H robotics and geospatial technologies on science, technology, engineering, and mathematics learning and attitudes. In J. Luca, & E. Weippl (Eds.), *Proceedings of world conference on educational multimedia, hypermedia and telecommunications* (pp. 447–452). Chesapeake, VA: AACE.

Nugent, G., Barker, B., Grandgenett, N., & Adamchuk, V. (2009). The use of digital manipulatives in k-12: robotics, GPS/GIS and programming. In *Frontiers in education conference*. FIE '09. 39th IEEE (pp. 1–6, 18–21).

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

OECD (2013). PISA 2012 Results: Ready to Learn: Students' Engagement, Drive and Self-Beliefs (Volume III). PISA, OECD Publishing; 10.1787/9789264201170s://www.oecd-ilibrary.org/education/pisa-2012-results-ready-to-learn-volume-iii_9789264201170-en Anxiety and Mathematics: An Update

Oliveira, C. (2013). Aprendizagem em ambientes de blended learning: Uma abordagem na formação contínua de professors. Master thesis in education, University of Lisbon.

Ortiz, A. (2011). Fifth grade students' understanding of ratio and proportion in an engineering robotics program. Proceedings from the 118th ASEE annual conference and exposition.

Öner, Yıldırım and Bars (2017). The effect of blended learning on students' achievement for the topic of quadratic equation in mathematics education. *Journal of Computer and Educational Research. 2*(4).

Özdemir, A. (2016). Ortaokul matematik öğretiminde harmanlanmış öğrenme odaklı ters yüz sınıf modeli uygulaması. Yayımlanmamış doktora tezi, Gazi Üniversitesi, Ankara.

Özdemir, M. Ç. (2019). Ters yüz edilmiş sınıf uygulamalarının geometri öğretiminde kullanılmasının matematik öğretmeni adaylarının geometriye yönelik tutumlarına etkisinin incelenmesi. Yayımlanmamış yüksek lisans tezi, Bayburt Üniversitesi, Bayburt.

Özdemir, M. Ç., Aydın, T., & Demir, B. (2020). A study for improving geometry attitudes of preservice mathematics teachers: An flipped classroom practice. *Eurasian Journal of Teacher Education, 1*(1).

Özdoğru, E. (2013). Fiziksel olaylar öğrenme alanı için lego program tabanlı fen ve teknoloji eğitiminin öğrencilerin akademik başarılarına, bilimsel süreç becerilerine ve fen ve teknoloji dersine yönelik tutumlarına etkisi. Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi Eğitim Bilimleri Enstitüsü, İzmir.

Pappas, C. (2005) The History of Blended Learning. [online] Available at: https://elearningindustry.com/history-of-blended-learning [Accessed 29 December 2020]

Papert, S. (1993). *Mindstorms: children, computers and powerfull ideias*, Basic Books.

Valsts-Pārbaudes darbi 2019./2020 (2020). National diagnostic work 2019/2020. Available https://www.visc.gov.lv/lv/valsts-parbaudes-darbi.

Pedro, A.,Matos, J.F.,Piedade, J., & Drotea, N. (2017) Probótica, Programação e Robótica no Ensino Básico-Linhas Orientadoras, Instituto de Educação da Universidade de Lisboa.

Pesen, A. (2014). Harmanlanmış öğrenme ortamının öğretmen adaylarının akademik başarısına, ders çalışma alışkanlıklarına ve güdülenme düzeylerine etkisi. Yayımlanmamış doktora tezi, Dicle Üniversitesi, Diyarbakır.

Pesen, A., & Oral, B. (2016). The effect of blended learning approach on academic success and motivation of teacher candidates. *Electronic Journal of Social Sciences. 15*(58).

Pinto, P. R. (Ed.). (2018). CNaPPES 2017 – Congresso Nacional de Práticas Pedagógicas no Ensino Superior. Instituto Politécnico de Setúbal.

Pizzie, R., & Kraemer, D. J.M. /2017). Strategies for remediating anxiety in high school math. Free preprint: https://psyarxiv.com/ye526/

Pombo, L. (2014). Avaliação em contextos de Blended learning no ensino superior, Doctoral thesis in education, University of Aveiro.

Pombo, L., & Moreira, A. (2013). An evaluation model for quality assurance of blended learning – exploring the lecturers' perspectives. In A. Moreira, O. Benavides, & A. J. Mendes (Eds.), Media in education: Results from the 2011 ICEM and SIIE joint conference (pp. 41–56). Springer.

Queirós, P., Martins, I., & Silva, M. P. (2012). Blended learning na formação de professores: Um percurso nos últimos 7 anos na Faculdade de Desporto da Universidade do Porto. In C. Leite & M. Zabalza (Eds.), Ensino Superior: Inovação e Qualidade na Docência (pp. 2580–2609). Universidade do Porto. Faculdade de Psicologia e Ciências da Educação. Centro de Investigação e Intervenção Educativas.

Ramos, J.L., & Espadeiro, R. G. (2016). Iniciação à Programação no 1.º ciclo do Ensino Básico. Estudos de avaliação. DGE – Direção Geral de Educação.

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551-554.

Riley, K. K. & Hunt, K. A. (2014) *Computational thinking for the modern problem solver*. CRC PressTaylor & Francis Group

Rubinsten O., & Tannock R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain Functions, 6*, 46. 10.1186/1744-9081-6-46. Free paper: https://behavioralandbrainfunctions.biomedcentral.com/articles/10.1186/1744-9081-6-46

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Sade, A. (2020). Kodlama öğretiminin 6. sınıf öğrencilerinin bilgisayarca düşünme becerilerine, matematik kaygı algılarına ve problem çözme algılarına etkisi. Yayınlanmamış yüksek lisans tezi, Mersin Üniversitesi, Mersin.

Sarıgöl, S. (2019). The role of parental math anxiety in students' math anxiety and performance, institute for graduate studies in social sciences. Unpublished master thesis, Boğaziçi University, İstanbul.

Scaradozzi D., Sorbi L., Pedale A., Valzano M., & Vergine C. (2015) Teaching robotics at the primary school: an innovative approach. *Procedia - Social and Behavioral Sciences. 174*, 3838-3846.

Schulz, W. (2005). Mathematics self-efficacy and student expectations. Retrieved from https://files.eric.ed.gov/fulltext/ED490044.pdf on 25.11.2020

Scovel, T. (1978). The effect of effect on foreign language learning: A review of the anxiety research. *Language Learning, 28*(1), 129-142.

Shields-Darla, J. (2006). Causes of math anxiety: The student perspective. Unpublished Phd thesis, Indiana University of Pennsylvania, United States.

Serin, M. K., & Korkmaz, İ. (2018). The effect of metacognitive questioning instruction performed in cooperative learning environments on the mathematical problem solving skills of 4th grade primary school students. *Elementary Education Online, 17*(2), 510-531.

Shimada, M., Kanda, T., & Koizumi, S. (2012). How can a Social Robot facilitate children's collaboration? *Social Robotics*, 98-107.

Skola2030 (2019). Valsts izglītības satura centrs. Retrieved from https://www.skola2030.lv/lv (in Latvian)

Smyrnova-Trybulska E., Morze N., Kommers P., Zuziak W., & Gladun M. (2017) Selected aspects and conditions of the use of robots in STEM education for young learners as viewed by teachers and students. *Interactive Technology and Smart Education. 14*(4), 296-312.

Souza, E., Amante, L., & Quintas-Mendes, A. (2020). Desenho e Avaliação de um curso b-learning para Formação de Professores e Educadores sobre Pensamento Computacional, Programação e Robótica. *RE@D - Revista de Educação a Distância e Elearning, 3*(1), 131–150.

Stergiopoulou, M., Karatrantou, M., & Panagiotakopoulos, C. (2017). *Educational robotics and stem education in primary education: A pilot study using the h&s electronic*. Educational Robotics in the Makers Era. Springer.

Sullivan, A., & Bers, M. U. (2016). Robotics in the early childhood classroom: learning outcomes from an 8-week robotics curriculum in pre-kindergarten through second grade. *International Journal of Technology and Design Education, 26*(1), 3-18.

Sullivan, A., & Bers, M. U. (2017). Dancing robots: Integrating art, music, and robotics in Singapore's early childhood centers. *International Journal of Technology and Design Education*, 1-22.

Sun, J. Chih-Yuan, Wu, Yu-Ting, Lee, Wei-I (2017). The effect of the flipped classroom approach to open course ware instruction on students' self-regulation. *British Journal of Educational Technology, 48*(3), 713-729.

Supekar, K., Iuculano T., Chen L., & Menon V. Remediation of Childhood Math Anxiety and Associated Neural Circuits through Cognitive Tutoring. J Neurosci. 2015 Sep 9; 35(36): 12574–12583

Şahin, F.Y. (2000). Matematik kaygısı. *Eğitim Araştırmaları, 1*(2), 75-79.

Şahin, E. (2019). Zeka oyunlarının ilkokul 4. sınıf öğrencilerinin problem çözme becerilerine ve problem çözme algılarına etkisi. Yayınlanmamış yüksek lisans tezi. Balıkesir Üniversitesi Sosyal Bilimler Enstitüsü.

Şentürk, B. (2010). İlköğretim beşinci sınıf öğrencilerinin genel başarıları, matematik başarıları, matematik dersine yönelik tutumları ve matematik kaygıları arasındaki ilişki. Yayınlanmamış Yüksek Lisans Tezi, Afyon Kocatepe Üniversitesi, Sosyal Bilimler Enstitüsü.

Şimşek, K. (2016). Harmanlanmış öğrenme ortamlarında bilgisayar cebiri sistemlerinin matematik öğretimine etkisi. Yayımlanmamış yüksek lisans tezi, Ege Üniversitesi, İzmir.

Talbert R. (2017). *Flipped learning: A guide for higher education faculty.* Stylus Publishing, LLC.

Talan, T. (2020). Investigation of the studies on educational robotic applications. *Journal of Education for Life, 34*(2), 503-522. doi: 10.33308/26674874.2020342177

Tan, C., Yue, W. G., & Fu, Y. (2017). Efectiveness of fipped classrooms in nursing education: Systematic review and meta-analysis. *Chinese Nursing Research, 4*(4), 192–200.

Tekin, O. (2018). Tersyüz sınıf modelinin lise matematik dersinde uygulanması: Bir karma yöntem çalışması. Yayımlanmamış doktora tezi, Tokat Gaziosmanpaşa Üniversitesi, Tokat.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Tobias, S. (1993). *Overcoming math anxiety.* New York: W.W. Norton & Company.

Tobias S., & Weissbrod, C. (1980). Overcoming math anxiety. *Harvard Educational Review, 50*(1), 63-70.

Turan, Z., & Göktaş, Y. (2015). Yükseköğretimde yeni bir yaklaşım: Öğrencilerin ters yüz sınıf yöntemine ilişkin görüşleri. *Journal of Higher Education & Science/Yüksekögretim ve Bilim Dergisi, 5*(2).

Ucgul, M., & Cagiltay, K. (2014). Design and development issues for educational robotics training camps. *International Journal of Technology and Design Education, 24*(2), 203-215.

Uusimaki, L., & Nason, R. (2004). Causes underlying pre-service teachers negative beliefs and anxieties about mathematics. *Proceedings of the 28th conference of the international group fot the psychology of mathematics education, 4*, 369- 376.

Ünsal, H. (2007). Harmanlanmış öğrenme etkinliğinin çoklu düzeyde değerlendirilmesi. Yayımlanmamış doktora tezi, Gazi Üniversitesi, Ankara.

Ünsal, H. (2012). The effect of blended learning on motivation and success. *The Journal of Turkish Educational Sciences. 10*(1), 24-27.

Waterworth Ch. (2014). *Pause, rewind my teacher: A flipped approach to learning.* Christopher Waterworth.

Wei, C. W., Hung, I. C., Lee, L., & Chen, N. S. (2011). A Joyful classroom learning system with robot learning companion for children to learn mathematics multiplication. *The Turkish Online Journal of Educational Technology, 10*(2), 11-23.

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of Science Education and Technology, 25*(1), 127-147.

Williams, D., Ma, Y., Prejean, L., Lai, G., & Ford, M. (2007). Acquisition of physics content knowledge and scientific inquiry skills in a robotics summer camp. *Journal of Research on Technology in Education, 40*(2), 201–216.

Williams, K., Igel, I., Poveda, R., Kapila, V., & Iskander, M. (2012). Enriching K-12 Science and Mathematics Education Using LEGOs. *Advances in Engineering Education, 3*(2), n2.

Wing, J. M., (2006) Computational thinking. Commun. ACM 49, 33. https://doi.org/10.1145/1118178.1118215

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366*(1881), 3717-3725.

Wu S.S, Barth M., Amin H., Malcarne V., & Menon V. (2012). Math anxiety in second and third graders and its relation to mathematics achievement. Front Psychol. 2012 Jun 7; 3:162. Free full text: https://www.frontiersin.org/articles/10.3389/fpsyg.2012.00162/full

Yenilmez, K., & Özbey, N. (2006). Özel okul ve devlet okulu öğrencilerinin matematik kaygı düzeyleri üzerine bir araştırma. Eğitim Fakültesi Dergisi, 19(2), 431-448.

Yıldırım, K. (2016). Denklemler konusunun etkinliklerle öğretiminin 7. sınıf öğrencilerinin cebirsel düşünme becerilerine ve matematik kaygılarına etkisi. Yayınlanmamış yüksek lisans tezi, Dokuz Eylül Üniversitesi, İzmir.

Yıldırım, A., Özgürlük, B., Parlak, B., Gönen, E., & Polat, M. (2016). TIMSS 2015 ulusal matematik ve fen bilimleri ön raporu 4. ve 8. sınıflar. Ankara: Milli Eğitim Bakanlığı Ölçme, Değerlendirme ve Sınav Hizmetleri Genel Müdürlüğü.

Yıldırım, İ., & Vural, Ö. F. (2016). Students' views about blended learning process integrated to mathematics education. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi (KEFAD), 17*(2).

Yolcu, V., & Demirer, V. (2017). A review on the studies about the use of robotic technologies in education. *SDU International Journal of Educational Studies, 4*(2), 127-139.

Young, C. B., Wu S. S., & Menon, V. (2012). The neurodevelopmental basis of math anxiety. *Psychological Science 23*(5), 492-501.

Yudin, A., Vlasov, A., Salmina, M., & Shalashova, M. (2020). *Evolution of educational robotics in supplementary education of children. robotics in education current research and innovations.* Springer.

Yuen, T. T., Mason, L. L., & Gomez, A. (2014). Collaborative robotics projects for adolescents with autism spectrum disorders. *Journal of Special Education Technology, 29*(1), 51-62.

Zakaria, E., & Nordin, N. M. (2008). The effects of mathematics anxiety on matriculation students as related to motivation and achievement. *Eurasia Journal of Mathematics, Science & Technology Education; 4*(1), 27-30.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Zbrodoff, J. N, & Logan, G. D (2005). What everyone finds: The problem size effect. InJ. I. D. Campbell (Ed.),Handbook of mathematical cognition(pp. 331–347). NewYork: Psychology Press

Zhong, B., & Xia, L. (2020). A systematic review on exploring the potential of educational robotics in mathematics education. *International Journal of Science and Mathematics Education, 18*(1), 79-101.

This project has been funded with support from the European Commission. This presentation reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.