RbtsInMath: Developing Mathematics Achievement through Using Robotics Applications in Flipped Learning

Content Development for Robotics Applications in Flipped Learning

LITERATURE REVIEW

Co-funded by the European Union

CONTEXT

Grant agreement	2022-1-PL01-KA220-HED-000086524
Programme	Erasmus+
Action	Cooperation partnerships in higher education
Project acronym	RbtsInMath
Project title	Developing Mathematics Achievement through Using Robotics Applications in Flipped Learning
Project starting date	01/11/2022
Project duration	28 months
Project end date	28/02/2025

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Table of contest

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

INTRODUCTION (CANAKKALE ONSEKIZ MART UNIVERSITESI)

Authors:

prof. dr Hasan Arslan

prof. dr M.Kaan Demir

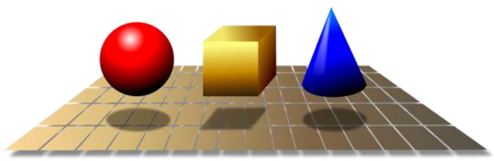
Yasemin A. Öztürk PhD

prof. dr Muzaffer Özdemir

Tech. Kadir Tunçer

Introduction to the project

The project to be supported will improve future teachers' skills in using robotics to teach and teach students mathematics as if they were playing a game. This will reduce students' math anxiety and prepare them for digital transformation and real life. This process in teaching mathematics can be described as a robot-friendly education process. Future teachers will learn how to run robotic applications to implement math education as part of flipped learning.



Aims and objectives

The goal of this project was stated as filling gaps in the skills of undergraduate students who will work in primary schools, in the processes of solving possible challenges related to math phobic students by developing:

A modular course curriculum that encourages the use of robotic applications for flipped learning in mathematics education in primary school

A virtual video library of robotics practices consisting of scenario-based learning and teaching processes

Teacher's Guide: Applying Reverse Learning through Robotic Practices in Elementary Schools

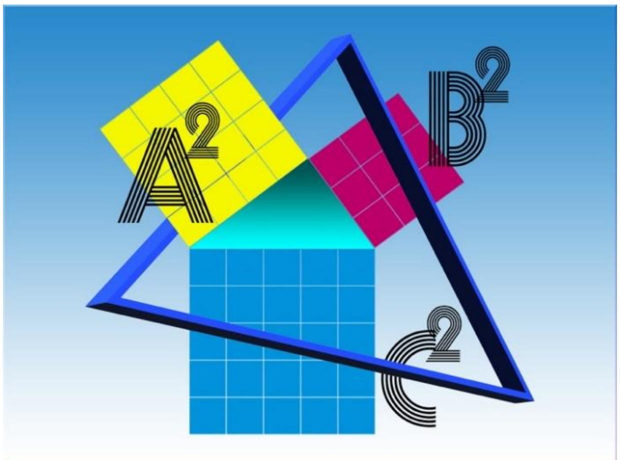
These objectives will ensure the implementation of the project's priorities. The first objective will be provided by an innovative curriculum that will allow the application of robotics in the learning and teaching process in primary schools. The second goal is the development of

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

robotic applications, and this process will create a virtual video library that future teachers will be able to freely use. and teachers will be free to use these apps in their math teaching activities. . User-friendly robotics will be part of the digital transformation in mathematics education. The third objective will develop the skills of future teachers who will be able to apply robotics in their teaching process.

Expected impacts of the project



The project involves pedagogical faculties of universities based on primary schools, because the period of primary school is the most appropriate period for the recognition and early intervention of children with mathematical anxiety. Taking into account the mentioned objectives, it is clearly stated that the target group of the project is 200 future teachers. Primary school teachers are the secondary target group. They will be invited to seminars and other activities. The main results of the project implementation are:

- Development of a modular curriculum with a robotic application for flipped learning
- Virtual Video Library with robotics practices
- Digital teaching guide supported by robotic applications

EU PERSPECTIVE

Education in mathematics is regarded as the key to success in today's workplace. Since we use math in every aspect of our lives, including practical everyday tasks and at work like problem-solving, managing personal finances, maintaining order, and using quantitative skills required by a large number of jobs, it is one of the most effective tools for reducing poverty, social exclusion, and inequality.

The future is in the hands of primary school pre-service teachers, thus they have a key role to play in meeting individuals' diverse needs. Given the various variances in how people learn mathematics, it's likely that most people would concur that certain math students experience excessive math anxiety,

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

which most likely results in a bad emotional state toward mathematics and poor performance in arithmetic. The majority of the time, math anxiety is a danger factor for some students for a thorough comprehension of mathematics, even though a reasonable level of math anxiety is expected to push students to study and focus on the subject at hand. As a result, it should be our aim as educators to investigate fresh methods for lowering math phobia in the context of teaching primary school mathematics. The usage of robots in the flipped learning method was chosen as a practical way to lower the amount of math anxiety among elementary kids among many other options.

MATHEMATICS EDUCATION IN PRIMARY SCHOOLS

2.1.ITALY (SCUOLA DI ROBOTICA)

Authors:

Filippo Bogliolo

Emanuele Micheli

2.1.1. General Objectives Of Mathematics Education In Primary Schools

Before describing the solutions proposed, and implemented, in Italian schools to mitigate mathematics anxiety, let us introduce the teaching of mathematics in primary school as a seen by innovative teachers.

According to many European evaluators, Italian primary schools excel in many aspects, including STEM subjects.

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 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

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

to understand, made up of formulas and algorithms to be memorized, not very creative, not very nice and not really easy.

So, 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.

2.1.2. Teaching Methods & Techniques Used

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 Maths, and pleasure in doing.

There are few school textbooks which show care for reflection, or the choice of 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.

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

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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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.”

Practices to release the mathematics anxiety of primary school children in Italy

In 2015, the Italian Ministry of Education released the National Digital School Plan (PNSD), a project designed to guide schools along a path of innovation and digitalisation, 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”.

Here we collected some innovative practices applied by teachers for the teaching of mathematics able to release maths 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

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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

"In Against the Maths 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.

Instrumental mathematics is based on

• formulas
• remembering
• exercises
• products

Relational mathematics is based on

• reasoning
• thinking
• problems
• processes it adapts better to new tasks, is easier to remember, 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."

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

2.1.4. General Status Of Achievement Levels In Mathematics In Terms Of Cognitive And Affective Processes

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 very 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 instalments. 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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

2.2.ROMANIA (UNIVERSITATEA LUCIAN BLAGA DIN SIBIU)

Authors:

Lia BOLOGA PhD

Diana BÎCLEA PhD

prof. Diana MIHĂESCU

2.2.1. General Objectives Of Mathematics Education In Primary Schools

Starting with the academic year 2022-2023 to implement a new reform in Romanian education. One of the very important is changing the structure of the school year, which was formed by 2 semesters and is now under the format of 5 modules separated by holidays. Primary education starts at the age of 6 in the preparatory class, then follows grades 1,2,3, and 4. In the primary cycle, children who have turned 6 in September are enrolled. In primary school, students do not have the required age at the end of the year, a final report is made in which several development indicators are indicated: assessment of physical, socio-emotional, and cognitive child's learning abilities and attitudes. The assessment of these characteristics is based on a methodology approved by the order of the Minister of Education.

From grade 1 onwards, students' results are expressed in single annual grades, by subject area. At the end of grades 2 and 4, the students take compulsory national written assessments in „Language and communication„ and „Mathematics„. The results of students are expressed in primary education by single annual grades by subject area, except in the preparatory class, where no grades are awarded. Based on the model for structuring the education system's aims, primary education's aims are represented by key competencies formed at an elementary level. The elementary level refers to the acquisitions acquired by the pupil at the end of primary school which enable him/her to carry out simple operations, in known, mainly concrete contexts.

(https://www.edu.ro/sites/default/files/DPC_31.10.19_consultare.pdf)

The primary school curriculum includes Mathematics and Environmental Exploration as part of the Mathematics and Natural Sciences curriculum area.

(https://www.edu.ro/sites/default/files/DPC_31.10.19_consultare.pdf)

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

The general objectives of the study of mathematics in primary education in Romania are: 1. Knowledge and use of concepts specific to mathematics; 2. Development of exploration/investigation and problem-solving skills; 3. Training and development of the ability to communicate using mathematical language; 4. Developing interest and motivation for studying and applying mathematics in various contexts

2.2.2. Teaching Methods & Techniques Used

There are several textbooks, books, workbooks with mathematics activities for primary schools but the Ministry of Education has approved only some of them and they can be accessed online (https://www.manuale.edu.ro/), these textbooks are also in digital format. In addition to the school textbooks, there are also educational software and auxiliaries are compiled with 3D educational games, each auxiliary contains CDs with various learning activities in the form of games in digital format. The teacher is free to choose the form of teaching and the techniques used. Considering the current reform "Romania Educata" and the objectives of the educational reform starting from 2022, the creation of a digitized school space is foreseen, so that the processes of implementation of learning programs and activities and the training of academic or professional skills are complete and in step with the evolution of society so that education can be carried out both through learning activities in formal and non-formal or informal contexts.

Currently, there are various funding projects that allow classrooms to be equipped with digital equipment for better teaching activities. Many schools in Romania have interactive whiteboards, projectors, computers, etc. in primary classes, combining traditional teaching methods with modern ones. Difficulties can exist in both rural and urban primary schools.

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

The mathematics curriculum for preparatory classes and grades 1 and 2 is approved by the Ministry of Education, minister Order 3418/2013, 6. general contents for preparatory classes, grade 1 and grade 2 based on the primary school curriculum (2013) (https://programe.ise.ro/): 1) Use of numbers in elementary calculations; 2) Highlighting the

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

geometrical characteristics of objects located in the surrounding space; 3) Identify phenomena/relationships/regularity/structures in the immediate environment; 4) Generate simple explanations using logic; 5) Solve problems by sorting and representing data; 6) Use conventional yardsticks for measurements and estimates

The general competencies for grades 3 and 4 based on the primary school curriculum (2013-2014) are: 1. Identify relationships/regularities in the immediate environment; 2. Using numbers in calculations; 3. Exploring geometric features of objects located in the immediate environment; 4. Using conventional yardsticks for measurement and estimation; 5 Solving problems in familiar situations.

The content of mathematics teaching in primary school is divided into domains. For the pre-primary, grade 1 and grade 2 are the domains: numbers, geometric figures and bodies, measurements, dates, life sciences, and physical sciences

The curriculum for grades 3 and 4 is regulated by Minister Order 5003/2014. The content of mathematics teaching for grades 3 and grade 4 is the areas: numbers and operations with numbers, intuitive elements of geometry, units and instruments of measurement, organisation and representation of data. For all the areas listed above, age-specific competencies are described.

2.2.4. General Status Of Achievement Levels In Mathematics In Terms Of Cognitive And Affective Processes

Starting in 2011 in Romania the National Assessment for grades 2,4,6 and 8 will be carried out. After obtaining the results of the assessments in grades 2 and 4, a report is drawn to improve the results. Measures are imposed to implement methodologies to detect errors and reasons for failure in students. Generally, the tests' structure reflects the IEA studies' principles. From 2021 essential changes have been made to the content of the assessments so that the assessment structure is competent and like international assessments. The adaptation of National assessments to the structure of external ones leads to an important fact in the idea of globalization and the alignment of the Romanian education system to an international one.

National assessment in grade 4 includes:

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

1) Mathematical content areas: a) Numbers 50%; b) Geometric figures and measurements 35%; c) Organizing data 15%/

2) Cognitive content areas - expected student behaviors in relation to mathematical content: a) Knowledge 40%; b) Application 40%; c) Reasoning 20%.

Table 1 gives the results of the grade 4 assessment in 2015-2021, in 2020 there was no assessment due to the Covid-19 pandemic, and for 2022 there are no official statistics et (https://www.rocnee.eu/index.php/dcee-oriz/rapoarte-evaluari-nationale-clasele-a-ii-a-a-iv-a-si-a-vi-a)

Table 1. The results of the grade 4 assessment in 2015-2021

Visiting skills	*The average percentage at the national level*							
	2015	2016	2017	2018	2019	2020	2021	2022
Natural numbers	72,7%	76,1%	64,9%	71,3%	65,8%	-	62,53%	-
Geometric figures, measures, fractions	61,6%	68,6%	62,3%	66,5%	71,5%	-	60,65%	-
Organizing data in tables	74,4%	73,1%	73,1%	75,9%	66,2%	-	73,71	-

As general conclusions based on the results obtained, the main problem is that the reasoning items have a low level of resolution in this content area as well, which is proof that the practical approach in the classroom is based very little on this type of cognitive area.

In the national assessment for grade 2, the following general areas are assessed: reception and comprehension of the written message. The important results are shown in Table 2.

Table 2. The result mathematics assessment of grade 2

Visiting skills	**The average percentage at the national level**					
	2015	2016	2017	2018	2019	2020
Using natural numbers in elementary calculus: -comparing numbers in the 0-1000 concentration - effect of additions and subtractions in the 0-1000 concert -effect of multiplications and divisions concert 0-1000	86,16% 73,49% 59,95%	90,89% 74,50% 68,67%	76,16% 72,57% 68,67%	92,64% 65,13% 69,32	92,37% 77,90% 78,86%	92% 68% 65%
Highlighting geometrical features of objects in the	88,10%	90,35%	79,09%	79,17%	94,04%	94,04%

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

surrounding space						
Solving problems based on sorting data	69,01%	65,80%	-	71,32%	-	81,25%
Organizing the data in a table	71,26%	82,87%	-	82,23%	81,25%	-

As a general conclusion, it is observed that 80% of the students in the second grade demonstrate that, at the end of this grade, they have developed the specific competencies for which they were assessed in terms of comprehension of a reading text (https://cdn.edupedu.ro/wp-content/uploads/2020/02/Rezultate-Evaluarea-Nationala-clasa-II-2019.pdf).

Romania participated in the TIMSS international assessment only with grade 8. Between 1995 and 2003, Romania scored between 472 and 475 points in mathematics, with scores dropping to 461 (2007) and 458 (2011) in 2007 and 2011, respectively. In 2019, Romania saw a slight increase to 479 points. Table 3 highlights the score ratio over the years 1995-2019 (Mullis, 2019).

A total of 199 schools participated in the TIMSS 2019 study, from which a total of 4485 grade 8 students, 196 principals, 214 math teachers, and 609 science teachers responded to the TIMSS tests and questionnaires. Romania participated only in the 8th module for mathematics and science. Students in grades 1-8 have access to a digital platform where they can test their literacy skills for free. It represents testing at the functional literacy level (brio.ro). The BRIO score is a percentile score: it shows how the tested pupil compares to all the other children in Romania who are in the same class as him/her.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

2.3.TURKEY (CANAKKALE ONSEKIZ MART UNIVERSITESI)

Authors:

prof. dr Hasan Arslan

prof. dr M.Kaan Demir

Yasemin A. Öztürk PhD

prof. dr Muzaffer Özdemir

Tech. Kadir Tunçer

2.3.1. General Objectives Of Mathematics Education In Primary Schools

Curriculums in Turkey have been prepared on the basis of "General Objectives of Turkish National Education" and "Basic Principles of Turkish National Education" expressed in Article 2 of the Basic Law of National Education No. 1739. In Turkey, primary school (1st, 2nd, 3rd and 4th grades), secondary school (5th, 6th, 7th and 8th grades) and high school (9th, 10th, 11th and 12th grades) are 12-year three stages. There is compulsory education. Moreover; As of the 2023-2024 academic year, there are studies to include the preschool 5 age group in the scope of compulsory education. All studies carried out with education and training programs within the scope of compulsory education; It aims to achieve the following objectives in a complementary way at pre-primary, primary and secondary education levels:

1. To support the healthy development of students who have completed pre-school education in physical, mental and emotional areas, taking into account their individual development processes.
2. Students who have completed primary school have acquired the basic level of verbal, numerical and scientific reasoning, social skills and aesthetic sensitivity that they will need in daily life, within the framework of moral integrity and self-awareness, within the framework of moral integrity and self-awareness, in accordance with the development level of the students who have completed the primary school. To ensure that they become healthy life-oriented individuals by using
3. To ensure that students who have completed secondary school become individuals who adopt national and moral values, exercise their rights and fulfill their responsibilities by developing the competencies they gained in primary school, and gain basic level skills and

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

competencies that are expressed in the "Turkish Qualifications Framework" and also in discipline-specific areas.

4. Students who have completed high school have adopted the national and spiritual values by developing the competencies they have gained in primary and secondary school, and have transformed them into a lifestyle, contributing to the economic, social and cultural development of our country as productive and active citizens, and also in the fields specific to disciplines. To ensure that they are individuals who have acquired basic level skills and competencies and are ready for a profession, higher education and life in line with their interests and abilities (MEB, 2018).

Turkish education system; It creates its education programs by taking into account the key competencies determined in the Turkish Qualifications Framework (TQF), which is based on equipping individuals with the skills they will need in their social, business, academic and personal lives at national and international level. The Turkish education system emphasizes mathematics education and includes it in the Turkish Qualifications Framework (TYÇ). One of the key competencies within the scope of TQF is Mathematical competency and basic competencies in science/technology. Emphasis is placed on developing mathematical thinking with mathematical competence, a process built on a solid arithmetic skill, and activity and knowledge on solving real-life problems.

Aim of Mathematics Education in Turkey in primary school:

When the curricula in Turkey are examined; taking into account the speed of change in technology and science, in line with the needs of the society and the individual, and contemporary learning-teaching theories and approaches; It is essential to raise entrepreneurial and determined individuals who can produce knowledge and use it functionally, have problem solving-empathetic thinking-critical thinking-communication skills. Within the framework of this basic understanding, curricula are prepared within the framework of 12-year compulsory education, primary school, secondary school and high school programs are prepared in such a way that each course has its own general objectives. Special skills related to mathematics in the mathematics curriculum; problem solving, mathematical process skills, communication, reasoning, mathematical modeling, association, affective skills, psychomotor skills, information and communication technologies (ICT).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

When the primary school Mathematics Curriculum in Turkey is examined, the general objectives of the Elementary School Mathematics Curriculum are: Understanding mathematical concepts and using these concepts in daily life; to use them effectively by developing their mathematical literacy skills; to be able to make sense of the relations of objects with each other and the relations between objects and people using mathematical language and meaning; Able to use mathematical terminology and language logically to explain and share mathematical ideas; to be able to express their own reasoning and thoughts easily in the problem solving process, to see the gaps or deficiencies in the reasonings of others; expressing concepts with different forms of representation; to be able to consciously manage their own learning process, to develop their metacognitive knowledge and skills; to use mental processing and estimation skills effectively; be able to develop the characteristics of being careful, systematic, responsible and patient; be self-confident in the mathematical problems they encounter by developing a positive attitude towards mathematics with their experiences in learning mathematics; being able to value mathematics by being aware of the fact that mathematics is a common value for all people; It is seen that there are thirteen such as being able to realize the relationship of mathematics with aesthetics and art and developing the skills of producing and using knowledge by doing research (MEB, 2018). In the general objectives of the mathematics course curriculum; Features such as understanding mathematics, using mathematics in daily life, solving problems, making decisions, thinking independently, communicating, expressing thoughts and making predictions based on data come to the fore (Yarış, 2022).

2.3.2. Teaching Methods & Techniques Used

The educational philosophy of progressivism lies at the heart of the education programs in Turkey, and the programs have been shaped on the constructivist approach, which takes into account individual differences and targets active learners, which has dominated teaching and learning fields throughout the 21st century (Tobias & Duffy, 2009). Constructivist approach is one of the most effective approaches in our age and it tries to explain how the individual learns by taking into account the latest developments in cognitive psychology. Constructivists claim that learning takes place in a process that includes previous knowledge schemas, that is, learning is fed by experiences and ideas (Batdı, 2023).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

When the application forms of constructivist learning approach in the field of mathematics are examined, Realistic Maths Education (RME) emerges. RME is a field-specific learning approach that starts with real-life situations and supports students to reach abstract concepts starting from their own knowledge (Van den Heuvel-Panhuizen, 2001). In this context, it is aimed to train students with high-level thinking skills such as problem solving, problem posing, reasoning, inference, and estimation, rather than students who perform mathematical operations based on repetition and memorization, through effective mathematics teaching (Yarış, 2022). In the mathematics curriculum in Turkey; Among the objectives of the mathematics course, the necessity of using real-life situations in mathematics teaching is emphasized, and it is stated that by including real-life situations in mathematics teaching, the meaning of mathematical concepts will be provided. In addition, the necessity of giving some subjects such as ratio and proportion in the mathematics curriculum together with real life situations is also included in the outcome explanations. Likewise, it was stated in the curriculum that the active participation of students in the lesson should be supported and that students should be allowed to create their own knowledge through their own experiences at this point (Tabak, 2019), and modern teaching methods were adopted in primary school mathematics education.

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

The education system in Turkey is planned as 12 years as primary and secondary education 4+4+4. Primary education covers the first eight years. 1-4. Intermediate elementary school, grades 5-8. It is the middle school level between grades.

There are four basic learning areas in the Mathematics Curriculum prepared by the Ministry of National Education for primary schools within the scope of the first 4 years. Sub-learning areas are also included under these learning areas.

Numbers and Operations learning area: Available at every grade level from Grade 1 to Grade 4. The sub-learning areas of the Numbers and Operations learning area are; natural numbers, addition with natural numbers, subtraction with natural numbers, multiplication with natural numbers, division with natural numbers, fractions and operations with fractions. Sub-learning areas of natural numbers, addition with natural numbers, subtraction

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

with natural numbers and fractions are at every grade level; sub-learning areas of multiplication with natural numbers and division with natural numbers at 2nd, 3rd and 4th grade levels; operations in fractions sub-learning area is only available at the 4th grade level.

Geometry Learning area: It is available at every grade level from Grade 1 to Grade 4. The sub-learning areas of the geometry learning area are; geometric bodies and shapes, spatial relations, geometric patterns and basic concepts in geometry. Geometric objects and shapes, spatial relations, geometric patterns sub-learning areas at every grade level; The basic concepts in geometry are sub-learning areas at the 3rd and 4th grade levels.

Measurement Learning Area: It is available at every grade level from 1st to 4th grade. The sub-learning areas of the measurement learning area are; measuring length, measuring circumference, measuring area, our money, measuring time, weighing, measuring liquid. Measuring length, measuring time, weighing, measuring liquid at every grade level; perimeter surveying and area surveying at 3rd and 4th grade levels; our coins are 1.2. and 3rd grade level.

Data Processing Learning Area: It is available at every grade level from Grade 1 to Grade 4. The sub-learning domain of the data processing learning domain is data collection and evaluation.

There are five basic learning areas in the Mathematics Curriculum prepared by the Ministry of National Education of secondary schools within the scope of the second 4 years. Sub-learning areas are also included under these learning areas.

Numbers and Operations learning area: Available at every grade level from Grade 5 to Grade 8. The sub-learning areas of the Numbers and Operations learning area are; natural numbers, operations with natural numbers, fractions, operations with fractions, decimal notation, percentages, factors and multiples, sets, integers, operations with integers, rational numbers, operations with rational numbers, ratio, ratio and proportion, exponential expressions, square root expressions. Natural numbers and fractions sub-field only at Grade 5 level; operations with natural numbers, operations with fractions, decimal notation sub-learning areas at 5th and 6th grades; sets, integers, ratio sub-fields only at Grade 6 level; Operations with integers, rational numbers, operations with rational numbers, ratio and proportion sub-learning areas are only at the 7th grade level; Exponential expressions and square root expressions sub-learning domains are only at Grade 8 level, percentages sub-

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

learning domain is at Grade 5 and 7 level; Multipliers and multiples are sub-learning domains at the 6th and 8th Grade levels.

Algebra Learning Area: It is available at every grade level from Grade 6 to Grade 8, except Grade 5. The sub-learning areas of the algebra learning area are; algebraic expressions, equality and equation, linear equations, algebraic expressions and identities, inequalities. Linear equations, algebraic expressions and identities, inequalities sub-learning areas are only at the 8th grade level; equality and equation sub-learning area is only at the 7th grade level; algebraic expressions sub-learning domains are at the 6th grade and 7th grade levels.

Geometry and Measurement Learning Area: It is available at every grade level from 5th to 8th grade. The sub-learning areas of the geometry and measurement learning area are; basic geometric concepts and drawings, triangles and quadrilaterals, triangles, length and time measurement, area measurement, geometric objects, angles, lines and angles, circle, circle and circle, fluid measurement, transformation geometry, polygons, views of objects from different directions, congruence and is similarity. Basic geometric concepts and drawings, triangles and quadrilaterals, length and time measurement sub-learning areas are only at the 5th grade level; circle, angles and fluid measurement sub-learning areas are only at Grade 6 level; lines and angles, circle and circle, polygons, views of objects from different directions sub-learning areas are only at the 7th grade level; triangles, transformation geometry, parity and similarity sub-fields are only at 8th grade level; area measurement sub-learning area at 5th and 6th grade levels; The geometric objects sub-learning area is available at every grade level, except for the 7th grade.

Data Processing Learning Area: It is available at every grade level from Grade 5 to Grade 8. The sub-learning areas of the data processing learning area are; data collection and evaluation is data analysis. Data collection and evaluation sub-learning area is at the 5th and 6th grade levels; The data analysis sub-learning area exists at every grade level, except for the 5th grade.

Probability Learning Area: It is only available at the 8th Grade level. The sub-learning area is; probability of simple events.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

2.3.4. General Status Of Achievement Levels In Mathematics In Terms Of Cognitive And Affective Processes

The international measurement and evaluation practices made to determine the quality of education enable countries to compare their achievements with other countries, to identify and analyze problems, to develop solution proposals, and to recognize the education systems of successful countries by other countries. The main ones of these evaluations are; Trends in International Mathematics and Science Study (TIMSS), Program for International Student Assessment (PISA), and International Computer and Information Literacy Study (ICILS).

TIMSS, which measures the achievements of 4th and 8th grade students in Mathematics and science, is one of the most comprehensive exams that has been applied every 4 years worldwide since 1995. Turkey also participated in TIMSS in 1999, 2007, 2011, 2015 and 2019. Turkey TIMSS results for 2011, 2015 and 2019 are presented in the Figure.

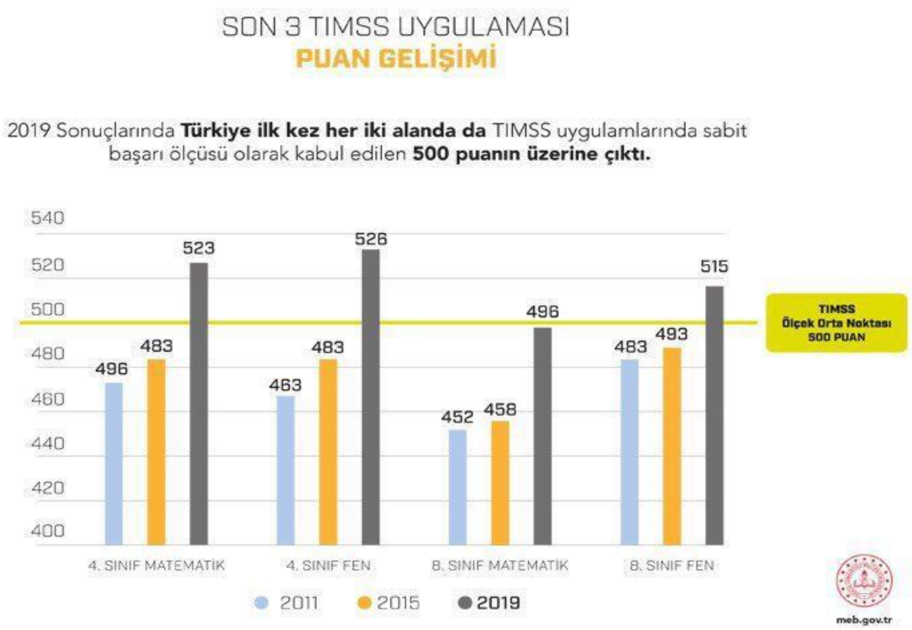


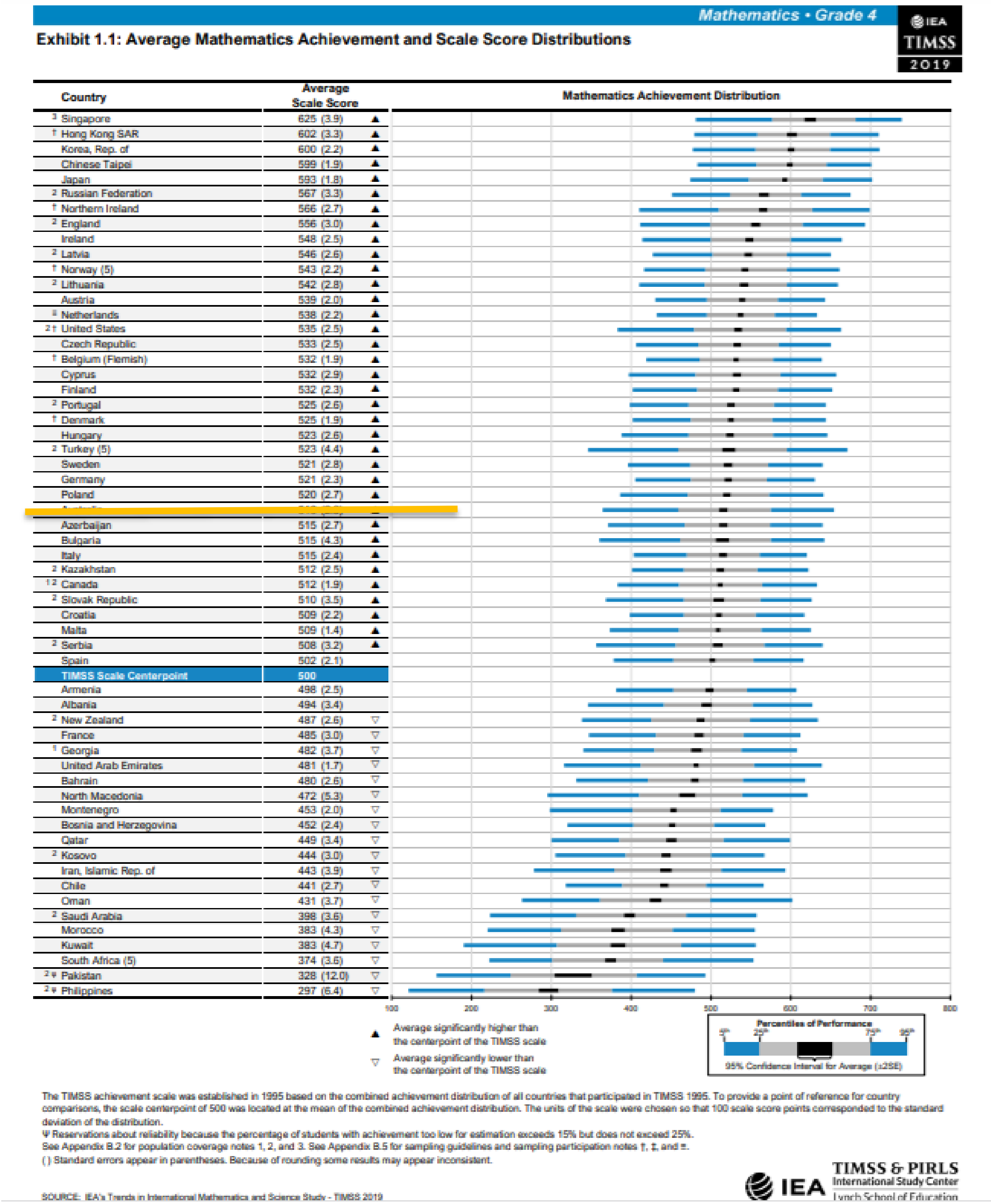
Figure 1. Turkey Last Three TIMSS Implementation Results

Turkey achieved the highest performance in the 2019 TIMSS application compared to all the applications it participated in. Turkey ranked 23rd among 58 participating countries in TIMSS 2019 with an average of 523 mathematics scores in the fourth grade. TIMSS 2019 8th grade performed at the midpoint level of the scale with an average of 496 mathematics points and ranked 20th out of 39 countries.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

TIMSS 2019 results are presented in Figure 2 for a clearer understanding of Turkey's position in TIMSS 2019 results compared to other countries.



Mathematics • Grade 4

Exhibit 1.1: Average Mathematics Achievement and Scale Score Distributions

Country	Average Scale Score	
3 Singapore	625 (3.9)	▲
† Hong Kong SAR	602 (3.3)	▲
Korea, Rep. of	600 (2.2)	▲
Chinese Taipei	599 (1.9)	▲
Japan	593 (1.8)	▲
2 Russian Federation	567 (3.3)	▲
† Northern Ireland	566 (2.7)	▲
2 England	556 (3.0)	▲
Ireland	548 (2.5)	▲
2 Latvia	546 (2.6)	▲
† Norway (5)	543 (2.2)	▲
2 Lithuania	542 (2.8)	▲
Austria	539 (2.0)	▲
≡ Netherlands	538 (2.2)	▲
2 † United States	535 (2.5)	▲
Czech Republic	533 (2.5)	▲
† Belgium (Flemish)	532 (1.9)	▲
Cyprus	532 (2.9)	▲
Finland	532 (2.3)	▲
2 Portugal	525 (2.6)	▲
† Denmark	525 (1.9)	▲
Hungary	523 (2.6)	▲
2 Turkey (5)	523 (4.4)	▲
Sweden	521 (2.8)	▲
Germany	521 (2.3)	▲
Poland	520 (2.7)	▲
[illegible]	[illegible]	▲
Azerbaijan	515 (2.7)	▲
Bulgaria	515 (4.3)	▲
Italy	515 (2.4)	▲
2 Kazakhstan	512 (2.5)	▲
1 2 Canada	512 (1.9)	▲
2 Slovak Republic	510 (3.5)	▲
Croatia	509 (2.2)	▲
Malta	509 (1.4)	▲
2 Serbia	508 (3.2)	▲
Spain	502 (2.1)	
TIMSS Scale Centerpoint	500	
Armenia	498 (2.5)	
Albania	494 (3.4)	
2 New Zealand	487 (2.6)	▽
France	485 (3.0)	▽
1 Georgia	482 (3.7)	▽
United Arab Emirates	481 (1.7)	▽
Bahrain	480 (2.6)	▽
North Macedonia	472 (5.3)	▽
Montenegro	453 (2.0)	▽
Bosnia and Herzegovina	452 (2.4)	▽
Qatar	449 (3.4)	▽
2 Kosovo	444 (3.0)	▽
Iran, Islamic Rep. of	443 (3.9)	▽
Chile	441 (2.7)	▽
Oman	431 (3.7)	▽
2 Saudi Arabia	398 (3.6)	▽
Morocco	383 (4.3)	▽
Kuwait	383 (4.7)	▽
South Africa (5)	374 (3.6)	▽
2 ψ Pakistan	328 (12.0)	▽
2 ψ Philippines	297 (6.4)	▽

The TIMSS achievement scale was established in 1995 based on the combined achievement distribution of all countries that participated in TIMSS 1995. To provide a point of reference for country comparisons, the scale centerpoint of 500 was located at the mean of the combined achievement distribution. The units of the scale were chosen so that 100 scale score points corresponded to the standard deviation of the distribution.

ψ Reservations about reliability because the percentage of students with achievement too low for estimation exceeds 15% but does not exceed 25%.

See Appendix B.2 for population coverage notes 1, 2, and 3. See Appendix B.5 for sampling guidelines and sampling participation notes †, ‡, and ≡.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

SOURCE: IEA's Trends in International Mathematics and Science Study - TIMSS 2019

IEA TIMSS & PIRLS International Study Center Lynch School of Education

Figure 2. TIMSS 2019 results

2.4.POLAND (SPOŁECZNA AKADEMIA NAUK)

Author

Paweł Pełczyński PhD

2.4.1. General Objectives Of Mathematics Education In Primary Schools

The aim of teaching mathematics is to develop in students mathematical intuitions appropriate to a given age. One of the tasks in the student's education process is to develop reasoning skills, analytical skills, strategic thinking (i.e. the ability to plan subsequent steps to solve the problem, as well as to divide the process of solving complex problems into stages) and the ability to critically look at the solution of the task. The second main objective is to develop accounting skills at a level that allows solving problems in other subjects in grades IV to VIII of the primary school. These objectives, specified in the core curriculum as general objectives, do not differ significantly from those set out in the previous core curriculum. (Podstawa programowa kształcenia ogólnego z komentarzem. Szkoła podstawowa. Matemetyka., 2017)

The teaching of mathematics at school is adapted to the specific stage of development and intellectual abilities of students. At the first stage of education, the teaching of mathematics is organized in such a way that students focus on references to the known reality, and the concepts and methods used are related to objects occurring in a familiar environment. Students have a chance to apply the acquired skills in concrete situations, and the search for answers to the questions posed is to help them organize their own learning and achieve new opportunities for action. In the case of mathematics, the last years of primary school are the time to introduce such concepts and properties that will allow you to improve abstract thinking, and consequently to learn to carry out reasoning and correct reasoning in new situations, as well as those related to complex and unusual issues. (Podstawa Programowa - szkoła podstawowa I-III, 2017)

The following types of educational objectives are pursued in Polish primary education:

I. Accounting skills

- Performing simple calculations in memory or in more difficult written activities and using these skills in practical situations

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

- Verifying and interpreting the results obtained and assessing the reasonableness of the solution

II. Use and production of information

- Reading, interpreting and processing data presented in different forms
- Interpreting and creating mathematical texts and graphical representation of data
- Using mathematical language to describe reasoning and results.

III. Use and interpretation of representation

- Use simple, well-known mathematical objects, interpret mathematical concepts, and manipulate mathematical objects
- Choosing a mathematical model for a simple situation and building it in different contexts, also in a practical context

IV. Reasoning and argumentation.

- Carrying out simple reasoning, giving arguments justifying the correctness of reasoning, distinguishing between evidence and example
- Seeing regularities, similarities and analogies and formulating conclusions based on them
- Using a strategy resulting from the content of the task, creating a strategy to solve the problem, also in multi-stage solutions and those that require the ability to combine knowledge from different branches of mathematics.

2.4.2. Teaching Methods & Techniques Used

Grades I to III of the primary school:

Education in grades I to III is provided in the form of integrated education. It includes functional, methodological, organizational and content integration. The basic form of organizing the child's work is a day of his multidirectional activity, not a classic school lesson. Integrated education is a concept of multifaceted activation of the child along with the need for constant diagnosis of its development, supporting functions stimulating development. The essence of mathematical education leads to the gradual discovery and knowledge of basic concepts such as number or arithmetic. This process is based on the child's mathematical intuition and the child's own thinking strategies. The teacher is obliged to plan classes in such a way that mathematical knowledge gradually forms a logically related

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

system leading from concrete-pictorial thinking towards conceptual thinking. This is helped by the spiral and linear arrangement of the content.

Grades IV to VIII of the primary school:

In grades IV–VI, when mathematics is taught primarily on specific objects, it is necessary to first of all take care of working on examples, without introducing an excess of abstract concepts. The advantage for the student is the opportunity to experiment with numbers, solve logical and logical-mathematical puzzles. In particular, solving equations by guessing is treated as a correct method in classes IV to VI.

In grades IV to VI, special caution is recommended when requiring the pupil to be the accuracy of mathematical language. The ability to use such mathematical concepts as: angle, length, field, algebraic sum is formed.

Most students use calculators or other electronic devices in practice. Nevertheless, the ability to perform calculations in memory, as well as in writing, is important. Memory calculations are introduced as useful in everyday life. Performing calculations independently, both memorized and written, gives students an idea of numbers and their sizes.

Abstract thinking is formed at the age of 11-15, but for many children at different rates, this does not necessarily mean greater or lesser mathematical skills. Due to the different speed of development of thinking of students of grades VII and VIII, as well as partly grade VI, it is recommended to teach mathematics in inter-branch groups at various levels, as it is practiced in teaching modern foreign languages. In practice, this is difficult to introduce, because it requires coordination of the schedule of different years of students. Students who have developed this thinking more quickly are advised to propose tasks that are more difficult and allow for deeper analysis of issues in order to properly stimulate their development. However, this requires the teacher to be more involved in contact with these students and is difficult to achieve in the context of conducting lessons in a class consisting of a large number of students.

Proving mathematical theorems are an important element of mathematical education. In elementary school, these tasks are limited to simple cases. An introduction to probability is preceded by tasks in which students perform experiments, such as multiple rolls of the dice. This allows to indicate the relationship between the frequency of the event and its probability.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

A special role in mathematical education is played by tasks in statistics. On the one hand, reading and presenting data links mathematics to everyday life and opens up a whole range of practical applications. It is desirable that a significant part of the tasks concern real data with their verifiable source. On the other hand, for example, operating with dependency graphs allows to intuitively master difficult and abstract concepts such as a function. (Podstawa programowa - matematyka. Klasy IV-VIII., 2017)

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

Education in primary school is the foundation of education. The school's task is to gently introduce the child to the world of knowledge, prepare them to perform the student's duties and introduce them to self-development. The most important goal of primary school education is to care for the integral biological, cognitive, emotional, social and moral development of the student. Education in primary school lasts eight years and is divided into two educational stages:

1) Education stage I, comprising grades I to III of the primary school – early school education;

2) Stage II of education in grades IV to VIII of the primary school.

In primary schools, at stage I, including grades I to III – early school education, it is provided in the form of integrated education. Mathematics is not distinguished here as a separate subject. In the field of mathematical knowledge, students at this stage acquire the ability to understand basic mathematical concepts and actions, learn to independently use them in various life situations, preliminary mathematization along with a description of these activities: words, image or symbol. They acquire the ability to ask questions, see problems, gather information needed to solve them, plan and organize activities, as well as solve problems, the ability to read simple mathematical texts, e.g. text tasks, puzzles and riddles, and symbols. (Podstawa Programowa - szkoła podstawowa I-III, 2017)

At the first stage, students in grades I to III learn:

- understanding spatial relations and grandiose features
- understanding numbers and their properties
- the use of numbers, the essence of mathematical operations – addition, subtraction, multiplication, division and relationships between them (the student multiplies and divides

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

numbers in his memory in the range of the multiplication table; multiplies in his mind by 10 numbers smaller than 20, solves equations with the unknown written in the form of a window, uses the equal sign and signs of four basic operations, adds and subtracts two-digit numbers, multiplies two-digit numbers by 2)

- reading mathematical texts
- understanding geometric concepts (the student recognizes geometric figures: rectangle, square, triangle, circle; draws sections at the ruler; draws rectangles by hand, measures the lengths of segments, sides of geometric figures, measures the circumferences of various figures using measuring tools, also in contexts from everyday life; calculates the circumference of a triangle and a rectangle with given sides, notices symmetry in the child's environment)
- applying mathematics in life situations and in other areas of education (the student classifies objects on the basis of separate features, divides into two and four equal parts, e.g. a sheet of paper, chocolate, uses the terms: half, two and a half, four equal parts, a fourth part or a quarter, performs monetary calculations, distinguishes denominations on coins and banknotes, reads the hours on the clock, performs simple calculations about time, uses time units: day, hour, minute, second, uses a stopwatch, writes down the dates of, for example, his birth or current date, uses the calendar, reads and writes Roman notation of numbers at least until XII, measures the temperature with a thermometer and reads it, makes estimates in various life situations, weighs, uses the terms: kilogram, decagram, gram, ton, knows the relationships between these units, measures liquids, uses the terms: liter, half a liter, quarter liter, uses checkers, chess and other board or logic games to develop strategic and logical thinking skills, uses acquired skills to solve problems, creative activities and explore the world).

At the second stage, students in grades VI to IV learn:

- operations with natural numbers in decimal positional system
- operations with integers
- fractions and decimals
- elements of algebra
- straight lines and segments

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

- angles, polygons and circles
- solids
- calculations in geometry
- practical calculations
- elements of descriptive statistics
- tasks described in text

Students in grades VII to VIII learn:

- powers with rational bases
- square roots and cube roots
- to create algebraic expressions with one and many variables
- to transform algebraic expressions
- percentage calculations
- equations with one unknown
- simple proportionality
- the properties of geometric figures on a plane
- polygons
- the number line, the coordinate system on a plane
- spatial geometry
- an introduction to combinatorics and probability
- to read data and elements of descriptive statistics
- circumference of a circle and the area of a circle
- symmetry
- advanced counting methods
- probability

2.4.4. General Status Of Achievement Levels In Mathematics In Terms Of Cognitive And Affective Processes

Cognitive processes, such as attention, memory, and problem-solving, are essential for learning and performing math. Students who have strong cognitive processes are better able

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

to understand and apply math concepts, solve math problems, and reason mathematically. Affective processes, such as motivation, interest, and self-efficacy, can also play a critical role in math achievement. Students who are motivated and interested in math are more likely to engage with the material and persist in solving math problems, while those with low self-efficacy may doubt their ability to succeed in math and give up easily. (Fuchs, 2016)

In Poland, as in many other countries, achievement levels in mathematics can vary widely depending on a range of factors, such as the quality of teaching, the availability of resources, and students' prior knowledge and experiences. Efforts are being made to improve math achievement by addressing both cognitive and affective processes. (Żeromska, 2013)

Overall, improving math achievement requires a holistic approach that considers both cognitive and affective processes, and that addresses the unique needs and experiences of each student.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

2.5. LATVIA (LATVIJAS UNIVERSITATE)

Authors

Ineta Helmane PhD

Linda Daniela PhD

2.4.1. General Objectives Of Mathematics Education In Primary Schools

In Latvia 9-year single structure basic education (primary and lower secondary education according) is compulsory for all children from the age of 7 and is generally completed till the age of 16, but may continue till the age of 18 (Education System in Latvia, 2020). In Latvia, children start school at the age of 7, where they follow general basic education programmes for 9 years. Basic education is delivered in two phases:

- 1st to 6th grades as primary education programme,
- 7th to 9th grades as basic or lower secondary education programme.

Complite basic education programmes are provided in educational institutions named pamatskola (basic schools). The educational programmes of the first six grades can be provided by primary schools (sākumskola). Secondary schools (vidusskola) may also provide a full programme of basic education or in any other educational institutions providing basic education programmes (Education System in Latvia, 2020).

In Latvia, the requirements for basic education are set out in the Cabinet of Ministers of the Republic of Latvia Regulation No 747 (Regulations on the State Standard for Basic Education and Model Programmes for Basic Education, 2018). The mathematics curriculum developed in Latvia (Matematika 1.-9. klasei. Sample curriculum, 2020) is recommended for the organisation of the mathematics teaching process in basic schools. The National Basic Education Standard determines the objectives and tasks, compulsory curriculum and the principles and procedures for assessment of basic education (Education System in Latvia, 2020).

The mathematics curriculum and standard for Grades 1–6 were not changed and these grades until 2019 continued to follow the mathematics curriculum approved in 2005 (Mathematics for Grades 1–9. Sample curriculum for mathematics, 2005; Avotiņa, 2022).

Since the school year 2022/2023, starting from pre-school to secondary school, education process is organized in accordance with the new curriculum for all levels of education

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

system. The National Centre of Education developed new curriculum for Education in the framework of the ESF project No 8.3.1.1./16/I/002 "Competence-based approach to Curriculum (School 2030)" (Skola2030, 2022).

The Mathmatics programme is providing 416 hours of mathematics teaching in Grades 1-3, 560 hours in Grades 4-6 and 525 hours in Grades 7-9. However, it is also possible for a school to organise teaching in a different way - 10% by reducing or increasing the number of lessons per mathematics subject.

The aim of mathematics education - for the student to acquire mathematical literacy, which means that the student, in situations involving mathematics, other areas of learning and real contexts, meaningfully using mathematical tools, makes calculations, processes data, uses properties of shapes, recognises relationships between quantities, makes general reasoning and mathematical modelling, chooses an appropriate approach or technique in problem situations, is aware of the need for a proof and constructs make reasonable judgements (Mathematics, 2019).

The objectives of mathematics education are to enable the student to

- use the language of mathematics by reading and writing down accepted symbols and explaining their meaning, constructing a mathematical text;
- to develop thinking skills by seeing and formulating relationships between quantities, patterns in the ordering of numbers and shapes, developing experience of making mathematically valid statements to make mathematical reasoning and problem-solving;
- perform operations with real numbers, modelling them practically and geometrically, using the properties of number composition and operations, choosing appropriate techniques;
- perform transformations of algebraic expressions, explaining the meaning of the expressions and the transformations by modelling them geometrically;
- solve problems with a practical or other learning context by constructing and solving mathematical model of a situation, evaluating the appropriateness of the mathematical solution to the context;
- develop skills in working with data by formulating an experiential research question, planning the acquisition of data, and practically acquiring, organising and analysing data;

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

• describe and apply the properties of 2D shapes and 3D space by investigating and formulating them, developing spatial concepts (Mathematics, 2019).

2.4.2. Teaching Methods & Techniques Used

Developing literacy involves deep learning - the process by which a learner develops the ability to generalise, to transfer new knowledge and skills to unknown situations (including real-life situations), placing at the forefront of learning the processes by which we acquire knowledge (how do we know?), not just the accumulation of a certain amount of content (what do we know?). By adopting a methodological approach that encourages learning by doing, the teacher enables the pupil to use and develop higher-level thinking skills (analyse, synthesise, evaluate, problem-solve), develops pupils' self-directed learning skills so that they develop a true understanding of the content they have learned and are able to solve complex problems in new situations and contexts.

To implement the learning-by-doing approach, the school provides an appropriate learning environment - meaningful, changing and exploratory, stimulating, safe and non-discriminatory, conducive to physical, mental and intellectual development. The learning environment shall be oriented towards mutual trust, cooperation and support, foster the development of pupils' independence and agency, and ensure pupils' representation and participation in decision-making, follow-up and monitoring. School work needs a change of emphasis to enable pupils to be immersed in the learning process:

• from the transfer and recall of ready-made knowledge to questioning, conversation, analysis of situations, productive tasks, enabling pupils to create new knowledge for themselves;

• from a frontal process to student involvement and cooperation;

• from memorising factual knowledge as a learning objective to using and creating knowledge in a variety of situations and contexts, so that learners have the experience of such practice and transfer;

• from primarily summative assessment to providing meaningful feedback to the learner on the learning process, the learner's reflection on his/her work and awareness of his/her own learning (Skola2030).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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

The content focuses on what is most important for the learner to develop competence as a complex learning outcomes over a longer period of time. The content is organised according to the key concepts or Big Ideas (BI) that the learner needs to acquire in order to develop a understanding of the world around her/him and of herself/himself in it. The Big Ideas are the structural framework of the compulsory curriculum; they describe the requirements for learning the curriculum, or the expected outcomes for the student at the end of a given level of education (Mathematics, 2019).

In mathematics education student develops an understanding about the Big Ideas of mathematics:

- the language of mathematics is used to communicate and scientifically describe concepts, ideas and solutions to problems.
- to solve a problem in mathematics is to see structures, systems, relationships, to make generalisations and to prove them.
- numbers are used to solve concrete, including practical, problems. For each activity with with numbers has a definite meaning and rules/algorithms for their execution.
- relationships between quantities are described by algebraic patterns and functions. Using these models to solve problems, they are transformed to ensure equivalence.
- data about objects, situations, events, processes can be processed mathematically, analysed to make informed decisions.
- the exploration of the properties of shapes, their positions, their characteristics and their magnitudes, enables solutions to specific problems, including practical problems, to formulate general conclusions about objects, space, shape (Mathematics, 2019).

Topic overview for mathematics for grades 1-6

1st Grade

1.1 How to tell and shows: how much, where, what?

1.2 How many in total, how many left?

1.3 How to measure lengths and how obtain symmetrical shape?

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

1.4 How do you write and compares numbers which are bigger than 10?

1.5 How to add and subtract numbers, biger than 10?

1.6 What does "that much more", "so much less"?

1.7 Where do we encounter large numbers?

1.8 How to describe and shapes?

2nd Grade

2.1 How to group objects?

2.2 How are different lengths?

2.3 How are the subtract two-digit numbers?

2.4 How do time calculations help planning?

2.5 How are expression develop?

2.6 How do describe shapes?

2.7 What does mean to multiply and divide by 2?

2.8 How do multiply and divide by 3, 4 and 5?

3rd Grade

3.1 How to multiply and divide by 6, 7, 8, 9 and 10?

3.2 How are all operations used?

3.3 How to make places plan?

3.4. What does a part mean of the whole?

3.5 What are the quantities describe a shape?

3.6 How do you count and subtract three-digit numbers?

3.7 How do spatial, 3D shape patterns?

4th Grade

4.1 How to count and subtract multi-digit numbers?

4.2 How multi-digit numbers are multiplied and divided by single-digit a number?

4.3 How are angles measured?

4.4 How multi-digit numbers are multiplied and divide by two digits number?

4.5 How to compare, add and subtract fractions?

4.6 What does part of a whole mean?

4.7 How to identify different shapes area?

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

4.8 What have shopping at and movement common in mathematical description? (Mathematics, 2019).

All the big ideas in mathematics teaching have a unifying aspect - the use of mathematics, which includes problem solving.

2.4.4. General Status Of Achievement Levels In Mathematics In Terms Of Cognitive And Affective Processes

The aim of the diagnostic work is to assess pupils' mastery of key competences according to the requirements of the national education standards and subject standards at the end of Grade 3, with a view to improving pupils' achievement by the end of the school year.

The diagnostic work includes three levels of tasks. Core requirements of the mathematics subject standard for learning the subject, at the end of Grade 3 are formulated in the following main content sections:

1. Developing a mathematical instrumentarium.
2. Application of mathematics to the analysis of natural and social processes.
3. Building and exploring mathematical models with mathematical methods.

For more detailed information, see the National Centre for Education's website under "General
Education. Content. Standards".

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

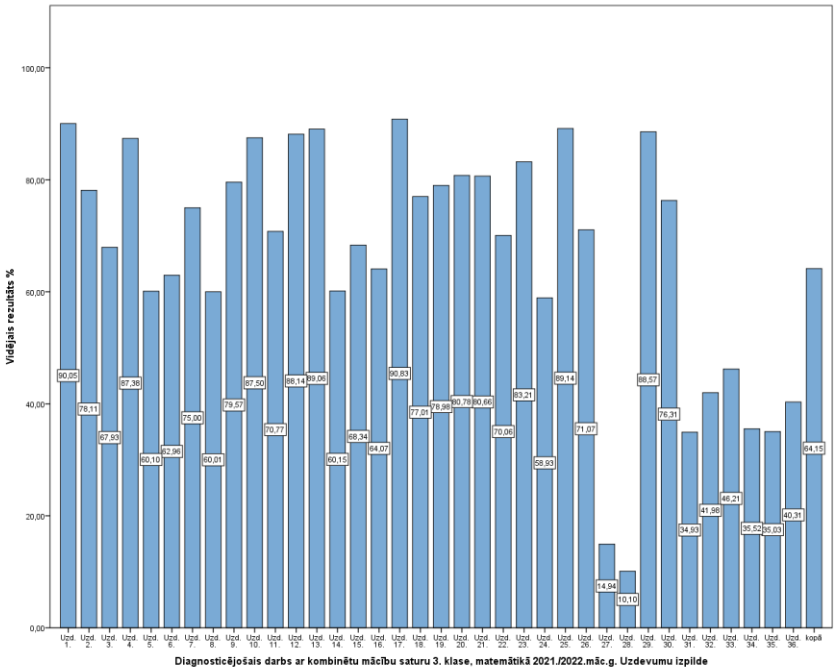


Figure 1 Results of Mathematics diagnistic work in 2021./2022. academic year

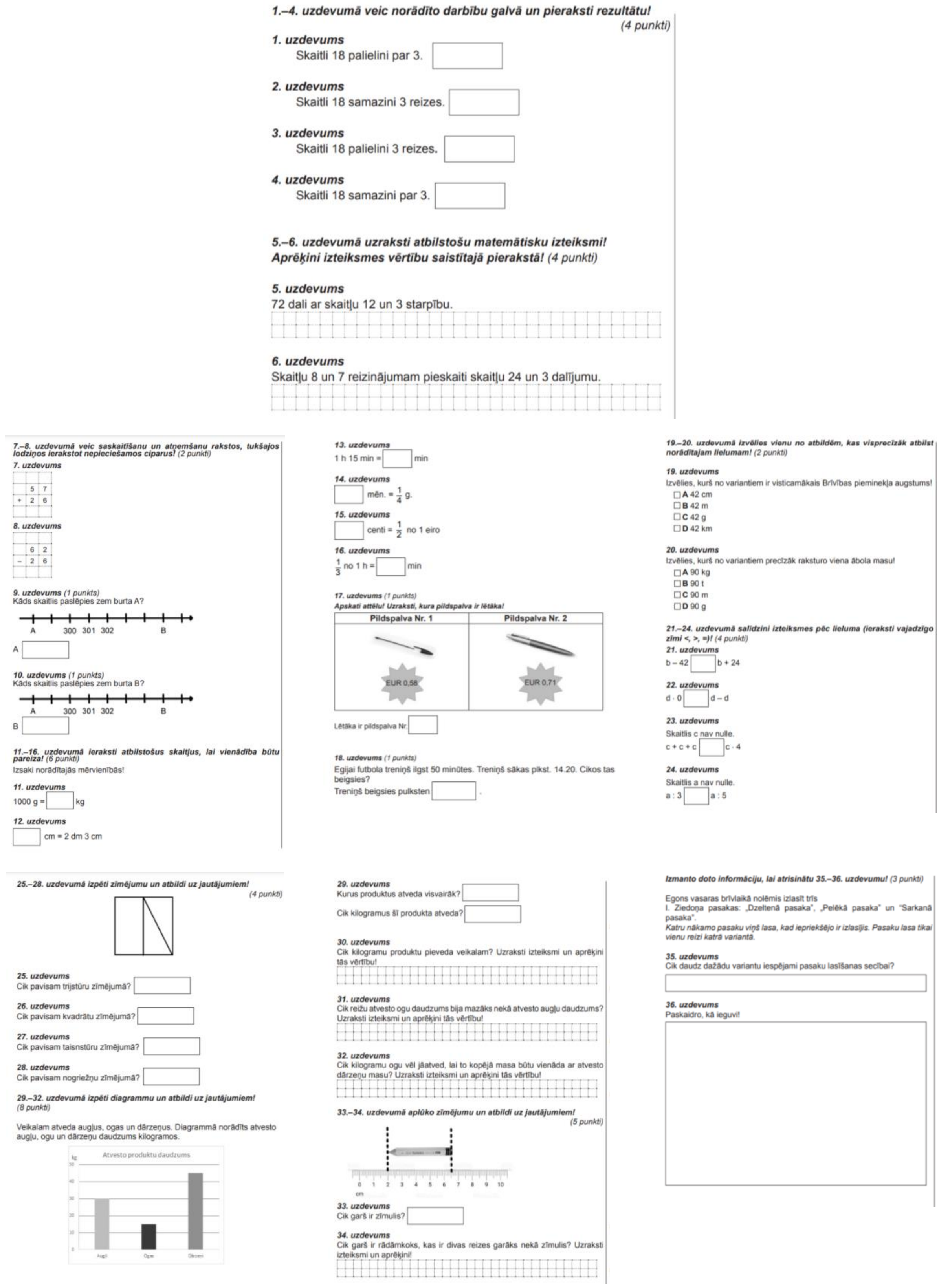
3rd Grade students have shown highest results in diagnostic work in mathematics:

- perform the given operation in the head and write down the solution in task 1, task 4;
- show the succession of numbers in a sequence of numbers in task 12;
- express the relationship between units of length in task 13;
- determine the value of an item in task 17;
- recognise geometric figures in a picture in task 25, task 28

The lowest results were observed in tasks requiring the identification of the properties of figures; task 27 and task 28.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524



1.–4. uzdevumā veic norādīto darbību galvā un pieraksti rezultātu! *(4 punkti)*

1. uzdevums
Skaitli 18 palielini par 3.

2. uzdevums
Skaitli 18 samazini 3 reizes.

3. uzdevums
Skaitli 18 palielini 3 reizes.

4. uzdevums
Skaitli 18 samazini par 3.

5.–6. uzdevumā uzraksti atbilstošu matemātisku izteiksmi! Aprēķini izteiksmes vērtību saistītajā pierakstā! *(4 punkti)*

5. uzdevums
72 dali ar skaitļu 12 un 3 starpību.

6. uzdevums
Skaitļu 8 un 7 reizinājumam pieskaiti skaitļu 24 un 3 dalījumu.

7.–8. uzdevumā veic saskaitīšanu un atņemšanu rakstos, tukšajos lodziņos ierakstot nepieciešamos ciparus! *(2 punkti)*

7. uzdevums
5 7
+ 2 6

8. uzdevums
6 2
− 2 6

9. uzdevums *(1 punkts)*
Kāds skaitlis paslēpies zem burta A?
A 300 301 302 B
A

10. uzdevums *(1 punkts)*
Kāds skaitlis paslēpies zem burta B?
A 300 301 302 B
B

11.–16. uzdevumā ieraksti atbilstošus skaitļus, lai vienādība būtu pareiza! *(6 punkti)*
Izsaki norādītajās mērvienībās!

11. uzdevums
1000 g = kg

12. uzdevums
cm = 2 dm 3 cm

13. uzdevums
1 h 15 min = min

14. uzdevums
mēn. = $\frac{1}{4}$ g.

15. uzdevums
centi = $\frac{1}{2}$ no 1 eiro

16. uzdevums
$\frac{1}{3}$ no 1 h = min

17. uzdevums *(1 punkts)*
Apskati attēlu! Uzraksti, kura pildspalva ir lētāka!

Pildspalva Nr. 1	Pildspalva Nr. 2
EUR 0,58	EUR 0,71

Lētāka ir pildspalva Nr.

18. uzdevums *(1 punkts)*
Egijai futbola treniņš ilgst 50 minūtes. Treniņš sākas plkst. 14.20. Cikos tas beigsies?
Treniņš beigsies pulksten .

19.–20. uzdevumā izvēlies vienu no atbildēm, kas visprecīzāk atbilst norādītajam lielumam! *(2 punkti)*

19. uzdevums
Izvēlies, kurš no variantiem ir visticamākais Brīvības pieminekļa augstums!
☐ A 42 cm
☐ B 42 m
☐ C 42 g
☐ D 42 km

20. uzdevums
Izvēlies, kurš no variantiem precīzāk raksturo viena ābola masu!
☐ A 90 kg
☐ B 90 t
☐ C 90 m
☐ D 90 g

21.–24. uzdevumā salīdzini izteiksmes pēc lieluma (ieraksti vajadzīgo zīmi <, >, =)! *(4 punkti)*

21. uzdevums
b − 42 ☐ b + 24

22. uzdevums
d · 0 ☐ d − d

23. uzdevums
Skaitlis c nav nulle.
c + c + c ☐ c · 4

24. uzdevums
Skaitlis a nav nulle.
a : 3 ☐ a : 5

25.–28. uzdevumā izpēti zīmējumu un atbildi uz jautājumiem! *(4 punkti)*

25. uzdevums
Cik pavisam trijstūru zīmējumā?

26. uzdevums
Cik pavisam kvadrātu zīmējumā?

27. uzdevums
Cik pavisam taisnstūru zīmējumā?

28. uzdevums
Cik pavisam nogriežņu zīmējumā?

29.–32. uzdevumā izpēti diagrammu un atbildi uz jautājumiem! *(8 punkti)*

Veikalam atveda augļus, ogas un dārzeņus. Diagrammā norādīts atvesto augļu, ogu un dārzeņu daudzums kilogramos.

Atvesto produktu daudzums

29. uzdevums
Kurus produktus atveda visvairāk?
Cik kilogramus šī produkta atveda?

30. uzdevums
Cik kilogramu produktu pieveda veikalam? Uzraksti izteiksmi un aprēķini tās vērtību!

31. uzdevums
Cik reižu atvesto ogu daudzums bija mazāks nekā atvesto augļu daudzums? Uzraksti izteiksmi un aprēķini tās vērtību!

32. uzdevums
Cik kilogramu ogu vēl jāatved, lai to kopējā masa būtu vienāda ar atvesto dārzeņu masu? Uzraksti izteiksmi un aprēķini tās vērtību!

33.–34. uzdevumā aplūko zīmējumu un atbildi uz jautājumiem! *(5 punkti)*

0 1 2 3 4 5 6 7 8 9 10
cm

33. uzdevums
Cik garš ir zīmulis?

34. uzdevums
Cik garš ir rādāmkoks, kas ir divas reizes garāks nekā zīmulis? Uzraksti izteiksmi un aprēķini!

Izmanto doto informāciju, lai atrisinātu 35.–36. uzdevumu! *(3 punkti)*

Egons vasaras brīvlaikā nolēmis izlasīt trīs I. Ziedoņa pasakas: „Dzeltenā pasaka", „Pelēkā pasaka" un "Sarkanā pasaka".
Katru nākamo pasaku viņš lasa, kad iepriekšējo ir izlasījis. Pasaku lasa tikai vienu reizi katrā variantā.

35. uzdevums
Cik daudz dažādu variantu iespējami pasaku lasīšanas secībai?

36. uzdevums
Paskaidro, kā ieguvi!

Figure 2 Tasks for Diagnitic work in mathematics in 2021./2022. academic year

https://www.visc.gov.lv/lv/20212022-macibu-gada-uzdevumi

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

MATHEMATICS ANXIETY

3.1. ITALY (SCUOLA DI ROBOTICA)

Authors:

Filippo Bogliolo

Emanuele Micheli

3.1.1. Definition (General)

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 disorganisation 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 and 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,

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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 behavioural 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 and 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.

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 (Menon, 2012).

Symptoms of maths 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 maths 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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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

3.1.2. Research/Practices to release the mathematics anxiety of primary school children

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 instrument for measuring maths anxiety became available. These studies showed a correlation between maths 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 maths 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:

• Does mathematics anxiety tend to contribute to poor performance?

• Does a knowledge of poor past performance induce the anxiety?

• Or, is the relation circular?

And the results appeared to be:

• Higher achievements consistently accompany reduction in mathematics anxiety;

• Treatment can restore the performance of formerly high-anxious students to the performance level of associated with low mathematics anxiety:

• 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

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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 less 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 behavioural than cognitive in nature” (emphasis added).

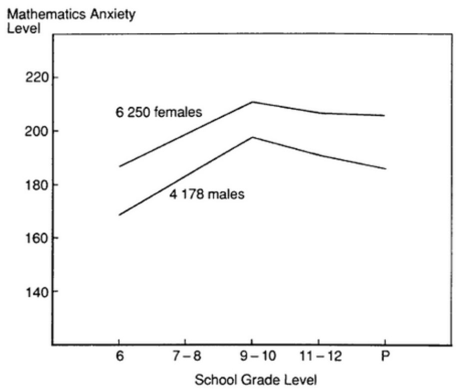


Figure 1. Average mathematics anxiety levels for Grades K–12 and undergraduate.

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 analyse 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

Co-funded by the European Union

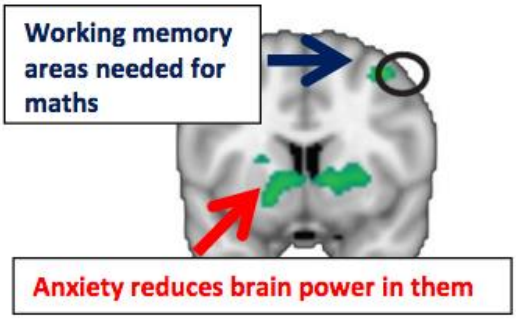
Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Laboratory, which is dedicated to the investigation of human brain function and dysfunction using a multidisciplinary approach that emphasizes a tight integration of cognitive, behavioural, 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. "

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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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

3.2. ROMANIA (UNIVERSITATEA LUCIAN BLAGA DIN SIBIU)

Authors:

Lia BOLOGA PhD

Diana BÎCLEA PhD

prof. Diana MIHĂESCU

3.2.1. Definition (General)

Anxiety is part of everyone's basic equipment because it helps us to do well in dangerous situations. It sharpens our senses and activates enough energy in the body to escape in case of danger or to fight with enough vigor (hence the fight or flight response). Anxiety is a pronounced emotional state, manifested by restlessness, and can be associated with palpitations, sweating and nervousness. Most of the time, it appears as a response to a stressful event or a prolonged state of tension. Other times, it appears as anticipation of a future stressor. Anxiety, more precisely anxiety disorder, can be found in several forms. According to Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM–5, 2013) this is the types of classification of anxiety: panic disorder, social anxiety disorder, generalized anxiety disorder, separation anxiety disorder, agoraphobia, and specific phobia. Benga et all (2010) considered that anxiety is one of the most common psychological and cognitive disorders in children and adolescents.

The mathematics is considered a fundamental discipline for the training of the new generation and plays an essential role in academic and professional success. At the same time, mathematics is seen as a factor that contributes to employment in well-paid jobs and

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

is an important component of fields such as science, technology, engineering and so on. Good results in mathematics are closely related to the students' attitude towards this discipline. Not all students consider mathematics to be useful and pleasant and for this reason some of them develop math anxiety.

Math anxiety is a negative emotional response caused by numerical tasks that affects math results (Sarkar et. al, 2014). Dreger & Alken were the ones who introduced the concept of math anxiety in 1957. The purpose of the study carried out by them was to identify the factors that facilitate and prevent students' anxiety towards mathematics (Khasawneh et al, 2021). Mathematical anxiety represents the fear of involvement and solving math problems. This type of anxiety is not a medical condition but is a way of describing the anxiety that occurs in a specific situation.

Mathematical anxiety can be analyzed at the following levels: 1) at the behavioral level (for example, avoiding or refusing to be involved in the activities of the class during the math class); 2) at the cognitive level (for example, worrying thoughts about doing homework, fear of assessment papers); 3) at the physiological level (for example, palpitations, sweating, perspiration of the palms etc.).

The factors that contribute to the emergence of mathematical anxiety are:

1. *the individual factor*. Here we can include cognitive, motivational, affective factors and physiological and genetic factors.

2. *the school environment*: a) the teaching staff (for example, teachers have an important role in creating a positive atmosphere in the classroom during math classes, thus reducing the level of math anxiety, evaluation methods); 2) the pears (for example, students may feel inferior to their peers when they make mistakes in math);

3. *the family environment:* the parents (for example, parents' math anxiety can cause math anxiety in children). According to Soni & Kumari (2017), parents' own perception of the value of mathematics has a significant impact on their children's motivation to pursue related fields in the future.

4. *the social/contextual environment.* The society can contribute to math anxiety through misconceptions about math or myths about math (for example, „You have to get the right result on the first try.",”You must have been born with a talent for math.” etc.).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Programme for International Student Assessment (PISA) report in 2012 PISA (OECD, 2013) investigated the phenomenon of mathematics anxiety among students across OECD countries and and 31 partner countries and economies, including Romania. The participants were 510,000 students aged between 15 years 3 months and 16 years 2 months. A percentage of 59% of the students investigated stated that they often worry about their participation in mathematics classes. In Romania, 75% of students expressed concern about mathematics classes and girls did not report stronger feelings of anxiety in mathematics than boys.

According to studies, math anxiety is showing up in classrooms primary school, and if not treated, it escalates to the high school level (Visu-Petra, 2018).

At the international level, there are very few studies that investigate math anxiety among primary school students.

3.2.2. Research/Practices to release the mathematics anxiety of primary school children

In the education system in Romania, the first foundations of mathematics are laid in the primary cycle. The main goal pursued in the teaching of mathematics is not limited to the informative side, but it mainly aims at the development of reasoning and the spirit of receptivity, of logical thinking skills, of clear and precise definition of notions, of creative adaptation to the ever-increasing demands of today's society.

In Romania, studies focus on test anxiety and not on math anxiety. To date, there is only one study regarding anxiety towards mathematics in primary school. The study was done by Tufeanu and Robu (2019) and investigated math anxiety and the variables associated with it that can have a negative impact on student performance. The participants in the study were 137 students (63 boys and 74 girls) from the fourth grade aged between 9 and 11 years, from eight public schools. The instrument used was the Romanian version of the Math Anxiety Questionnaire (MAQ). According to the study it can be observed that: over 37% of the students surveyed expressed fears about the tests they had to give math; 27.8% of students reported feeling scared during math tests; both girls and boys tended to report moderate to low levels for the math anxiety dimensions with no significant differences.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

One of the most important projects related to reducing math anxiety in primary school students, called "Reducing math anxiety in primary school children", was developed by Visu-Petra (2020). The project demonstrated that working memory training significantly improved student performance and reduced math anxiety.

3.3. TURKEY (CANAKKALE ONSEKIZ MART UNIVERSITESI)

Authors:

prof. dr Hasan Arslan

prof. dr M.Kaan Demir

Yasemin A. Öztürk PhD

prof. dr Muzaffer Özdemir

Tech. Kadir Tunçer

3.3.1. Definition (General)

The affective characteristics of individuals in a field affect their cognitive field skills in that field. Positive affective features increase the interest in the field, make the individual active and willing in learning, and make the learning process more efficient (Çelebi & Su, 2022). Since the affective characteristics of the field of mathematics enable students to realize their desire to know, understand and use mathematics, it is very important to increase their belief that they can learn the lesson fondly and willingly (Dağbaşı, 2017).

It can be difficult from time to time to turn one's true potential into performance. One of the important reasons for this is anxiety, which is one of the affective characteristics. Anxiety is a universal emotion and experience experienced in some periods. Defining anxiety is not as easy as it is thought and it includes many elements such as worrying about the future, sadness, fear, not being able to predict what will happen, not being able to meet expectations (Arslan, Dilmaç & Hamarta, 2009, as cited in Ekin & Şanlı-Kula, 2022). Mathematics is one of the branches of science that every individual encounters when they start primary school, which is in all areas of education life, which some people can do with pleasure, and some do not like because they cannot do it, and feel anxiety (Altun, 2000). Dowker, Sarkar, and Looi (2016) also emphasized that individuals have more anxiety and more negative attitudes towards mathematics than other disciplines. Studies indicate that

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

the main problems and failures experienced in the field of mathematics are the anxiety experienced by the students (Ekin & Şanlı-Kula, 2022). Mathematics anxiety negatively affects mathematics learning processes (Sloan, Daane & Giesen, 2002; Vinson, 2001), individuals with mathematics anxiety have less experience with mathematics, and this lack of experience reduces mathematical fluency and mathematics learning and success (Cates & Rhymer, 2001). 2003; Dowker et al., 2016).

The first definition of mathematics anxiety in the literature; It is the definition made by Dreger and Aigen in 1957 as "emotional reactions syndrome against mathematics and arithmetic" (Baloğlu, 2001). Ma and Hu (2004) reported math anxiety as disturbing emotions caused by confusion while performing a math-related homework or task or solving a problem (Dede & Dursun, 2008), while Ashcraft and Moore (2009) stated that it includes situations such as numbers and mathematical calculations. defined as giving negative reactions to situations (Bostancı, 2020). Briefly; Mathematics anxiety is a universal condition that leads to negative emotions such as fear, panic, and helplessness developed by experience.

3.3.2. Research/Practices to release the mathematics anxiety of primary school children

The sample of Tabakçı (2018)'s study in which he examined the learned helplessness and mathematics anxiety of primary school students consisted of 415 4th grade students. The results obtained from the research; The students' math anxiety is high, they have a moderate level of learned helplessness, and there is no statistically significant relationship between math anxiety and learned helplessness.

Kaba and Şengül (2018) examined the relationship between math anxiety and mathematical understanding; He worked with 466 secondary school students. Research results; As the grade level increases, math anxiety decreases, mathematical understanding and math anxiety differ significantly according to grade level, and there is a high level of positive correlation between math anxiety and mathematical understanding.

Mert and Baş (2019) studied 1553 secondary school students in their research; examined whether gender and grade level affect students' math anxiety and metacognitive awareness levels. In the study, it was determined that students with high mathematics achievement

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

had less mathematics anxiety, in general, as mathematics anxiety increased, success decreased significantly, and metacognitive awareness significantly explained mathematics achievement and mathematics anxiety.

In the study of Hangun (2019) in which he examined the effects of robotic coding training on 6th grade students' math anxiety and success, programming self-efficacy and STEM attitudes; It was determined that robot programming trainings significantly reduced math anxiety and significantly increased programming self-efficacy and STEM attitude scores.

The sample of Gürel and Özdemir (2019) is 6-8. In his research, which consisted of 815 secondary school and 140 gifted students studying in the grade range; The aim of this study was to determine the mathematics anxiety levels of gifted and secondary school students. According to the research results; It was observed that gifted students had lower anxiety than secondary school students, the level of anxiety did not differ significantly according to the grade level variable, while the anxiety level of secondary school students was significantly lower in small classes. It was determined that the anxiety levels of female students were higher in both groups, but this difference was not significant. In addition, it has been determined that while mathematics achievement affects the mathematics anxiety scores of secondary school students, success does not constitute a significant factor in gifted students.

Akkurt (2021) in his study aiming to determine the mathematics anxiety levels of 4th grade students and the ideas of classroom teachers about teaching mathematics; He worked with 501 4th grade students and 250 classroom teachers. The results obtained from the research; students have low level of mathematics anxiety, and the classroom teachers find themselves sufficient in the teaching method they use in mathematics lessons and in measuring success.

Ekin and Şanlı-Kula (2022) investigated the exam and math anxiety of 11310 secondary school students studying in secondary schools in Turkey. As a result of the research, students' math anxiety; There is no significant difference according to gender, using the internet or computer programs to learn mathematics, students with a low average monthly income have the highest mathematics anxiety, there is a statistically significant difference between the average of mathematics anxiety according to the education level of the parents of the students, and their parents are literate. It was concluded that the students who did not have the highest mathematics anxiety were found.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Çelebi and Su (2022) examined the relationship between mathematics-oriented epistemological beliefs, mathematics self-efficacy perceptions and mathematics anxiety; It has been observed that there is a positive relationship between mathematics-oriented epistemological beliefs and mathematics self-efficacy, and a negative relationship between mathematics anxiety and mathematics self-efficacy, and a negative relationship between mathematics self-efficacy perception and mathematics anxiety.

Kartal, Baltacı and Yıldız (2022) worked with a total of 506 secondary school students, 284 of whom were girls and 222 of them, in their study titled "Adapting the Mathematics Self-efficacy and Anxiety Questionnaire into Turkish and Examining its Relationship with Mathematical Self-concept". The results obtained from the study; While grade level and gender caused differences in the averages, it was seen that grade level had no effect on the self-efficacy, anxiety and self-esteem of both female and male students. As the grade levels of both male and female students increased, their averages decreased. In addition, it was seen that mathematics self-efficacy and anxiety were significant predictors of mathematical self, and the strongest predictor was self-efficacy.

Dölek (2022) worked with 425 primary school 3rd and 4th grade students and 425 parents to determine the effect of parents' math anxiety on primary school students' math achievement, attitude and anxiety. The results obtained from the study show that parental anxiety affects students' mathematics achievement and mathematics attitudes negatively, 3rd grade students' math anxiety positively, and 4th grade students' math anxiety negatively.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

3.4. POLAND (SPOŁECZNA AKADEMIA NAUK)

Author

Paweł Pełczyński PhD

3.4.1. Definition (General)

Math anxiety is a feeling of fear, tension, or nervousness that arises when a person is faced with a math problem or a math-related task. It is a psychological condition that can affect people of all ages and backgrounds and can have a negative impact on their ability to learn and perform math. (Helen Moriah Sokolowski, 2017)

Students with math anxiety may experience physical symptoms such as sweating, rapid heartbeat, or even panic attacks when faced with a math problem. They may also have negative thoughts and beliefs about their ability to solve math problems, which can lead to avoidance of math-related tasks and decreased performance in math. (Math anxiety: What it is and how to overcome it, 2022)

Math anxiety can be caused by a variety of factors, including past negative experiences with math, a lack of confidence in one's math abilities, or pressure to perform well in math from parents or teachers. It can also be a result of cultural or societal beliefs about math and its perceived difficulty. Fortunately, math anxiety can be treated and overcome with the help of various strategies, such as exposure therapy, cognitive-behavioral therapy, relaxation techniques, and academic support programs. (Supekar, 2015)

3.4.2. Research/Practices to release the mathematics anxiety of primary school children

In general, treatment of math anxiety may involve a combination of strategies that can help children develop a positive attitude towards math and build their confidence. These strategies include cognitive-behavioral therapy, exposure therapy, relaxation techniques, and academic support programs. (Ehmke, 2022)

In Poland, schools rarely provide extra support for students who struggle with math, such as additional tutoring or small-group instruction. Some teachers use innovative teaching methods and materials to help students learn math in a more engaging and interactive way. Overall, the treatment of math anxiety in Poland is similar to approaches used in other

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

countries and involve a combination of different strategies tailored to the individual needs of each student. Some initiatives focus on use innovative teaching methods. For example, teachers use games, puzzles, and other activities that involve numbers to make math more fun and less intimidating. They also incorporate real-life examples and situations to show how math is relevant to everyday life. (Bunda, 2009) Overall, the goal of these initiatives is to create a positive and supportive learning environment for students and to help them develop confidence in their math abilities.

3.5. LATVIA (LATVIJAS UNIVERSITATE)

Authors

Ineta Helmane PhD

Linda Daniela PhD

3.5.1. Definition (General)

Definitions of anxiety cover disorders of everyday life, emotional reactions to threats and psychopathological disorders. Wide and general definitions describe anxiety as an emotional response to a real or imagined threaten or stressful event (Sun & Alkon, 2014). Anxiety can also be characterised by context or stimuli, such as social situations, maths tests (Dorenkamp et al., 2018).

Everyone can experience anxiety at certain times, but the frequency, duration and intensity can vary between individuals. Anxiety in the present moment reflects an emotional response that has been triggered by the threat of an existing situation (Croyle et al., 2012; Potvin et al., 2013). It disappears once the threatening situation has passed. Social anxiety referred to fears about social situations in which a person may have to interact with other individuals, be the centre of attention, or perform in front of an audience (American Psychiatric Association, 2013). Although anxiety episodes do not obviously affect daily life, their effects may be less visible, such as impaired cognitive function. Anxiety has the effect of interfering with working memory, resulting in reduced information processing capacity and efficiency (Bunce et al., 2008).

In a situation of anxiety, a person may experience a variety of symptoms, such as:

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

- neurological - headaches, dizziness, sleeplessness, fainting
- digestive - sickness, vomiting, diarrhoea, dry mouth, indigestion
- respiratory - breathlessness, rapid breathing
- heart - chest pain, heart palpitations, tachycardia (cardiac arrhythmia), high blood pressure
- muscles - tiredness, trembling
- skin - sweating or itching
- urogenital system - frequent urination, sudden urination (Testa, Giannuzzi, Sollazzo, Petrongolo, Bernardini, Daini, 2013).

Maths anxiety is a negative emotion experienced during maths learning and testing, characterised by worrying thoughts, emotional fearfulness, distress and somatic symptoms (Hopko et al., 2003). There are several types of mathematics anxiety: anxiety experienced when taking the test and anxiety experienced in classroom situations (Hopko et al., 2003; Cipora et al., 2015), anxiety experienced when performing basic mathematical operations and manipulating with numbers (Kazelskis, 1998; Baloglu, Zelhart, 2007). Piemēram, test anxiety is caused by assessments that are perceived as threatening. Test anxiety can be a condition of anxiety that is a passing reaction as a result of being tested and a trait that reflects a personality characteristic that continues after any specific testing situation (Croyle et al., 2012). Maths anxiety is related to maths calculations. Individuals with math anxiety tend to avoid any context involving mathematics in any form, e.g. individuals with math anxiety are much less likely to engage in math-related activities. When solving mathematics problems, individuals with high maths anxiety tend to react quickly and ignore precision (Ashcraft, 2002). Maths anxiety can affect maths performance by causing learning avoidance (Hembree, 1990; Namkung et al., 2019; Ramirez et al., 2018) and reduce cognitive resources during problem solving (Ashcraft, Krause, 2007; Suarez-Pellicioni et al., 2014). Typically, there are gender differences in the experience of mathematics anxiety. Women are more frequently reported to have maths anxiety (Hembree, 1990; Ma, 1999).

Anxiety can arise from all kinds of mathematical tasks, also from activities that require spatial thinking, which is also defined as spatial anxiety (Ferguson et al., 2015). Statistical anxiety is a current issue among students. Statistical anxiety is an anxiety arising from statistical courses or statistical analyses (Cruise et al, 1985) and statistical anxiety is different from anxiety or maths anxiety (Onwuegbuzie, Wilson, 2003; Paechter et al, 2015). Up to 80%

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

of students experience statistical anxiety, which leads to delays in their studies. Statistics is considered to be the most anxious course in the degree programme (Chew, Dillon, 2014). Global anxiety is a type of anxiety that does not fall into one specific anxiety category (trait, position, social, test or maths anxiety) and it can combine two or more categories into one value (Dorenkamp et al., 2018).

3.4.2. Research/Practices to release the mathematics anxiety of primary school children

There is no research about that topic in Latvia.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

USE OF ROBOTICS IN PRIMARY SCHOOL MATHEMATICS EDUCATION

4.1. ITALY (SCUOLA DI ROBOTICA)

Authors:

Filippo Bogliolo

Emanuele Micheli

4.1.1. General Overview

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 tools for perceiving, interpreting and interpret and connect natural phenomena, concepts and man-made natural phenomena, concepts and man-made artefacts, 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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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.

4.1.2. Mathematics and Computational Thinking

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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Basic Principles of The Use of Robotics in Mathematics Education in Primary Schools

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 memorisation 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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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.

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 recognised 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 characterised 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

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

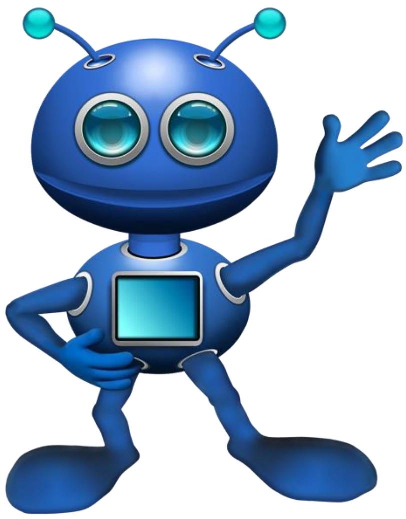
overall mathematical abilities, while they are on average better at applying this knowledge (only 2 points higher on the application-specific scale than on the total mathematics scale, but the difference is significant).

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.

4.1.4. National and Private Initiatives for the Use of Robotics

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.

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

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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.

4.1.5. Other Applications (Serious Computer Games, VR, AR, etc.)

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.

4.2. ROMANIA (UNIVERSITATEA LUCIAN BLAGA DIN SIBIU)

Authors:

Lia BOLOGA PhD

Diana BÎCLEA PhD

prof. Diana MIHĂESCU

4.2.1. General Overview

Starting in 2016, a gigantic project to digitize the education and training system is being launched in Romania. The idea came from the Presidential Administration in the context of a project "Romania educated". This project has been in debate for two years, and starting in 2018 its implementation started.

Based on the new project, a pupil in primary school will have the necessary skills to balance the theoretical and practical knowledge accumulated, reinforce their own life behaviors, and be useful wherever they choose to continue their studies further. Complemented by the following competencies: 1) through the course to acquire age-appropriate cyber security

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

knowledge; 2) to excel in areas in which they have particular skills or talents/to which they feel an attraction; 3) be able to use information technology at an age-appropriate level.
Thus, Romania is looking for methods and strategies to improve the education system in line with new technologies and European standards.

4.2.2. Mathematics and Computational Thinking

In Romania, primary school pupils in some schools have the opportunity to develop their digital skills, and for primary school pupils, additional or optional hours are allocated for the development of digital competence. In various primary schools, pupils learn the first programs and games that they use especially in mathematics, where they can apply their acquired knowledge by applying it to various games. Some schools in Romania have classrooms with digital technologies that teachers use in the teaching process. Teachers also use various educational platforms that students apply both in class and at home. From primary school onwards, the basis for developing logical and computational thinking skills is laid. In the primary grades, children are at the age of boundless creativity and imagination. This is the period when they absorb everything and want to know everything. One of the techniques of computational development is STEM education. A new but very important concept in education in Romania.
STEAM education has several benefits, among the most important (Li, 2022): a) increased collaboration; b) increased creativity; c) development of scientific investigation skills. In the development of scientific investigation skills, we refer specifically to computational thinking, to develop computational thinking, it is important to formulate the tasks correctly for the students (Gasnas, 2022; Marin, 2003). The notion of computational thinking was introduced by Papert (Papert, 1980) and continued by Wing (Wing, 2006). Therefore, it is very important to develop students' problem-solving skills so that they are capable (Gasnas, 2022): 1) formulate a problem - consider the scope and details of a real-world problem; define questions in relation to the problem; 2) translate problems into mathematical language - creating or choosing an appropriate mathematical model, and then formulating the question as a mathematical problem within the model; 3) calculate the solution - use mathematical

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

techniques to solve the mathematical problem; 4) evaluate the solution - interpret the mathematical solution in its original context.

4.2.3 Basic Principles of The Use of Robotics in Mathematics Education in Primary Schools

Starting from computational thinking we reach the development of logical thinking for the formation of algorithmic thinking (Marin, 2003). Mathematics is the discipline that lays the foundations of logical thinking. It is good that mathematical knowledge that is organized algorithmically and applied in practice. Using robots, we can make a direct link between logical, computational thinking, and algorithmic organization.

The mathematics studied in school pursues two important aspects, referring to the aims pursued namely (Timofte, 2022): 1) the formation of intellectual capacities and specific abilities, such as logic in thinking, appreciation of the truth, respect for correctness, etc.; 2) the understanding of some basic notions necessary for the deepening of higher mathematics, possibly to be studied later, respectively notions necessary for the study of other sciences.

Based on Piaget's stages of cognitive development (https://www.britannica.com/topic/human-behavior/Piagets-theory), i.e. at the concrete operational stage of cognitive development, we can say that students in primary school can be taught to program, to have concrete experiences in programming with the help of robotic toys. Pupils can think of paths for robots, they can travel these paths visually or physically, and pupils can think of which direction they can take when they reach an intersection, repeat the path or continue the journey (Demo, 2008). We can classify the application of robots by grade level.

Reviewing robotics for grade 2 with an understand/use-modify-create strategy (Baek 2019): 1) developing logic and algorithmic thinking; 2) training in the basics of programming; 3) development of planning, and modelling skills; 4) data processing; 5) developing the ability to abstract and find patterns; 6) the ability to solve practical problems quickly; 7) mastering the ability to outline, model, and type; 8) knowledge and ability to use universal sign systems (symbols); 9) developing the ability to evaluate the process and outcomes of own activities.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

For 7-8 years old (grades 1 and 2) the work plan can be organized on several aspects (Baek, 2019): a) conversation; b) game; c) creating a robot according to the model; d) creative modelling.
For this age group, special equipment is needed to create robots so that they can perform simple assembly operations and memorize the components of a robot. Using robots for this age group develops algorithmic thinking, students can express their thoughts freely and begin to develop the ability to work in teams. Recommended robots are those that are not yet equipped with additional sensors and sensing devices (Baek, 2019). If we talk about robotics for 9-11 years old (grade 3 and grade 4), we can talk about the more advanced stage of using robots. The tasks can become more complicated, and the construction of robots more complex, especially if students have some experience and know what tasks they have to do (Bellas, 2019).

4.2.4. National and Private Initiatives for the Use of Robotics

Romania participates in international robotics competitions since 2011, in the 2011-2012 season a Romanian team participated in the FIRST Tech Challenge, this competition promotes STEM education among students, parents, teachers, and communities in general. (https://ro.everybodywiki.com/FIRST_Tech_Challenge_Rom%C3%A2nia)
The FIRST Tech Challenge Romania Robotics Championship has several phases. First the regional phase and then the national phase. In present Romania, there are national robotics competitions approved by the Ministry of National Education including NEXTLAB.TECH is the largest school robotics competition in Romania for students aged 8 to 16. The competition is an online robohackathon. There are teachers in schools who take care of the children's teams for the robotics competitions. There are also private institutions running various robotics competitions and their application, of course, these private schools also compete in national competitions.
Winners of national competitions have also participated in international competitions (China, Philippines 2018, Denmark, Hungary, China 2019, Canada, Philippines 2020, Russia 2021, Germany, Hungary- 2022), in recent years also online (https://nerdvana.ro/despre-noi/istoric-performante/). A bigger advance in robotics schools was in 2018 when robotics

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

schools appeared on the market: Legooschool, Robohub, and Nextlab. tech, ROBBO, and others.

4.2.5. Other Applications (Serious Computer Games, VR, AR, etc.)

In Romania, there are other types of competitions that develop computational and algorithmic thinking. The National Minecraft for Education Contest has been organized in Romania since 2018. Contest in which teachers have been trained with the agreement of the Ministry of Education and which has taken an educational side through which not only programming but also mathematics, and sciences are taught. Children since primary school play the Minecraft game. Every second boy in primary school can tell or show how to play such a game.

Another national competition is Super Coders launched in 2014, the SuperCoders is based on programming with the free program Scratch.

4.3. TURKEY (CANAKKALE ONSEKIZ MART UNIVERSITESI)

Authors:

prof. dr Hasan Arslan

prof. dr M.Kaan Demir

Yasemin A. Öztürk PhD

prof. dr Muzaffer Özdemir

Tech. Kadir Tunçer

4.3.1. General Overview

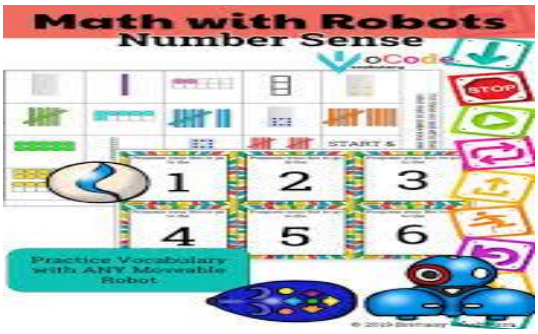
The use of technology is advancing and differentiating at a dizzying pace in our age. As these changes manifest themselves in every field, they also bring about great changes in the field of education. Because one of the leading goals of education is to provide individuals with desired behaviors in line with the needs of society, and it is an obligation to prepare individuals for the future by considering the human characteristics needed by information age societies. These obligations enable studies in the field of education to progress in parallel with the development of technology in Turkey as well as all over the world, and

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

bring along new teaching approaches in the field of using computers in education. Robotic Coding is one of these innovative teaching approaches that are very popular today.

Robotic coding technologies can be considered as modern mind tools that can be used in the problem solving process, encouraging individuals to work collaboratively, enabling them to participate in academic discussions, and providing the skills to discover and structure knowledge and apply what has been learned (Ching et al., 2019; Jonassen, 2000; Kopcha et al. al., 2017; Petre & Price, 2004; Yuen et al., 2014).



Within the scope of supporting robotic coding teaching; Many programming tools have been developed that can be programmed using the drag-and-drop method with Arduino, Mbot and Lego robots etc. many teaching tools, robotic circuits such as Tinkercad, Mblock, Scratch for Arduino etc. with code blocks. With these tools, coding skills are supported; By producing prototypes, problem solving-logical reasoning, creative thinking, algorithmic thinking, computational skills are developed, abstract concepts can be taught through experiential learning, and outputs can be reached to find solutions to current problems (Anistyasari & Kurniawan, 2018; Monroy-Hern´andez & Resnick, 2008; Proctor & Blikstein, 2018; Rowe et al., 2017; Yağcı, 2019). Those who learn through robotic coding have the opportunity to learn by doing.

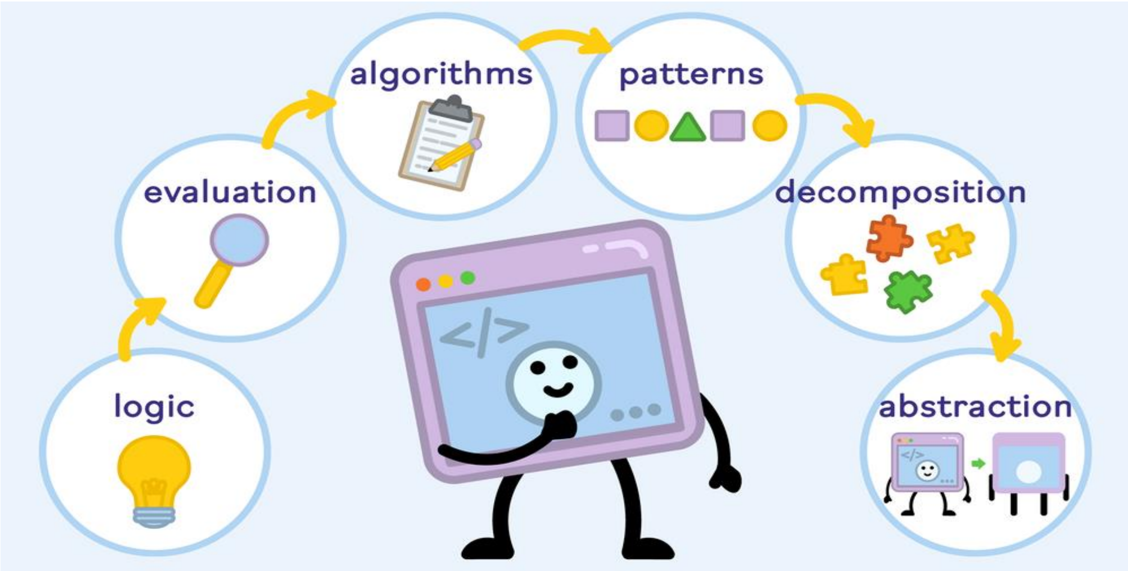
4.3.2. Mathematics and Computational Thinking

Today, with the development of technology, computer science also comes to the fore. The use of computers in the problem solving process has revealed the concept of "computational thinking". Computational thinking skills are defined within the scope of 21st century skills. Wing (2006) states that computational thinking is not only about computer science but also engineering-mathematics etc. He states that it is also related to fields and that it is a thinking skill that everyone who is a digital citizen should have.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

The concept of Computational Thinking was first used by Papert in 1996 and can be defined as "problem solving, system design and understanding human behavior by using the concepts of computer science" (Gülbahar, Kert & Kalelioğlu, 2019). Computational Thinking; It consists of logic, evaluation, algorithms, patterns, decomposition and abstraction.



Şekil 3. Computational Thinking

Lockwood and Mooney (2017) emphasize that there are many studies showing that computational thinking can be integrated into fields such as Mathematics, Physics, Biology and English. Mathematics is at the center of rapidly changing science and forms the basis for explaining the world (Aminger et al., 2021). It is very important to include computational thinking strategies in learning environments where mathematics is the basis of scientific developments and problem solving (Wilkerson & Fenwick, 2017). Computational thinking and mathematics; It is closely related to the analysis-interpretation of data and the transmission of information. Students use mathematical representations, data images, simulations, and graphical representations when they have difficulty expressing findings in text or spoken language. These sub-tools used in the mathematics course overlap with the sub-components of computational thinking and show that the two fields are interconnected (Bozal, 2022). Mathematical thinking is seen as a fundamental factor in learning programming skills (Sung, Ahn & Black, 2017), computational thinking allows the mathematical models established in computational thinking to be compared with what is

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

known about the real world and to see whether the models are meaningful (Aminger et al., 2021). Robotic coding is one of the most effective approaches to use computational thinking in mathematics or to develop computational thinking through mathematical activities.

4.3.3 Basic Principles of The Use of Robotics in Mathematics Education in Primary Schools

Robotic technologies are very effective tools in the realization of practice-based learning in the fields of engineering, science, technology and mathematics (Mataric, Koenig, & Feil-Seifer, 2007). There are many studies conducted in Turkey that reveal the positive effects of robotic activities on learning and affective characteristics in mathematics education in primary and secondary schools. These studies show that the use of robotic coding in mathematics education provides opportunities for active and collaborative learning experiences, develops motor skills, is effective in concretizing concrete concepts, increases the motivation for learning mathematics, makes the learning process more enjoyable, develops creative problem solving and analytical thinking skills, and develops academic academic skills in mathematics. They have shown that it increases their success and affects their learning transfer and computational thinking positively (Çankaya, Durak & Yünkul, 2017; Göksoy & Yılmaz, 2018; Kasalak, 2017; Kazez & Genç, 2016; Somyürek, 2015; Tekin & Keser, 2020; Yolcu, 2018).

Thanks to robotic applications, children can concretely explore abstract concepts that appear as learning difficulties in mathematics (Çınar, 2020; Nugent et al., 2010); they can use them in the solution of problems related to integers, ratio-proportionality, measurement, geometry, algebraic equations within the framework of active learning principles (Stripling & Simmons, 2016). By employing robotic applications in the teaching process with the Z and alpha generation children, who are children of the information technology age, interest in mathematics can be increased, and negative attitudes and anxiety, which are obstacles to children's learning, can be minimized. However, it is not correct to say that using robotic applications alone improves mathematical learning.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

4.3.4. National and Private Initiatives for the Use of Robotics

It can be said that studies on the integration of robotic technology into education emerged in the early 1980s (Çınar, 2020). The use of robotic technologies in education first emerged in the USA more than 20 years ago (Chung, Cartwright & Cole, 2014) and has spread rapidly all over the world. For example, the Scratch platform, which is one of the robotic coding platforms, has more than 70 language options and the fact that it is free provides ease of access to the application (Balcı, 2022). Many countries have turned to robotics technologies to increase the interest in applied education (Leonard et al., 2016). The number of countries that add robotics courses to their education curricula and encourage the opening of after-school robotics courses is increasing (Mataric, Koenig & Feil-Seifer, 2007). The UK Ministry of Education launched a new curriculum for the mathematics course in 2016 and also included algorithm training in the curriculum. Countries that are members of the European Union have focused on integrating Computational Thinking into training programs related to robotic coding education. Especially in Finland, students encounter programming and algorithmic thinking in their primary school years (Balcı, 2022). Robotic coding in Turkey, as in other countries; It is widely used in private and public institutions in the field of education by taking into consideration within the scope of STEM education. Many educational institutions in Turkey have included robotics and coding education in their curricula; uses many different educational tools such as lego robot, arduino, mbot. These tools can usually be programmed by text-based or block-based coding. These coding tools are generally aimed at young learners and are programmed with the drag-and-drop method of a number of code blocks instead of writing complex code sentences that make up a computer program.

The aim of the trainings is to contribute to the development of mathematical thinking skills in addition to improving coding methods in students. After the 2000s, the Turkish Ministry of National Education focused on the development of computational thinking skills, robotic coding, programming, and STEM education, which are also considered within the scope of 21st century skills. It strives to integrate these skills into other courses as well as to include them in the curriculum as separate courses. Teaching about robotic coding in Turkey; "Problem Analysis and Solving Approaches", "Algorithm and Strategy Development

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

(algorithm creation logic, pseudocode, flowcharts, etc.)", "Programming", "Software Project Development, Implementation and Dissemination" and "Information Technologies and Software" are presented in the course content. Since 2013, this course is 2 hours and is compulsory for the 5th and 6th grade levels of secondary school, and it is an elective course for the 7th and 8th grades. In these courses, computer-free coding and platforms such as Scratch and code.org are used for coding training, while microprocessor or microcontroller cards and equipment such as arduino, Lego, Micro:bit are used for robotics training (Yalçın & Akbbulut, 2021).

1. Information Technologies and Software Curriculum, students;
2. As digital citizens, they should be individuals who have a good understanding of technological concepts, systems and processes.
3. To use information technologies effectively and appropriately,
4. To access, research and use Internet-based services,
5. To create a general understanding and technical knowledge of computer science,
6. To acquire and develop problem solving and computational thinking skills,
7. To be able to follow and evaluate the reasoning process,
8. Gain collaborative working skills, benefit from social environments and share what they have learned as a part of the learning process,
9. Searching for learning opportunities on the internet,
10. To be able to express verbally and visually by developing an understanding of algorithm design,
11. To be able to choose and apply the appropriate programming approach to solve problems,
12. Creating technical knowledge on programming,
13. To be able to use at least one of the programming languages,
14. To carry out studies on product design and management,
15. Develop innovative and original projects for the solution of problems encountered in daily life (problems faced by elderly and disabled people, etc.) (MEB, 2018).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

4.3.5. Other Applications (Serious Computer Games, VR, AR, etc.)

Block-based programming tools, which are frequently used in robotics and coding applications, are more suitable for young children (primary school) to use (Strawhacker & Bers, 2015). For high school and higher level individuals who have reached the age of abstract operations, it is more appropriate to use basic arduino kits to gain programming skills (Yolcu & Demirer, 2017). Because, students who will do robotic coding with basic arduino kits should have knowledge of the characteristics of sensors and equipment they will use in robotic projects, as well as some basic electronic concepts such as resistance, current, voltage, serial and parallel circuit setups.

4.4. POLAND (SPOŁECZNA AKADEMIA NAUK)

Author

Paweł Pełczyński PhD

4.4.1. General Overview

The use of robotics in primary school mathematics education is becoming increasingly popular in Poland, as it can make learning math more engaging, interactive, and fun for students. Robotics can help students develop problem-solving skills and critical thinking abilities, as they learn how to program and control robots to solve math problems.

In Poland, several initiatives have been launched to promote the use of robotics in primary school mathematics education. For example, some schools have implemented robotics workshops or clubs where students can learn how to program and control robots to perform various math-related tasks. These workshops often involve hands-on activities and challenges, such as building and programming a robot to solve a mathematical equation or navigate a maze. (Robotyka, 2023)

Additionally, some schools have started using robotics kits and software in the classroom to teach math concepts such as geometry, algebra, and measurement. For example, students may use robotics kits to build and program robots that can measure distance, angles, and other geometric properties, or to solve algebraic equations. (Zasoński, 2017) Overall, the use of robotics in primary school mathematics education can provide students with a fun and

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

interactive way to learn math, while also helping them develop important skills such as problem-solving, critical thinking, and collaboration.

4.4.2. Mathematics and Computational Thinking

In Poland, mathematics and computational thinking are important subjects taught in primary schools to help children develop basic numeracy and problem-solving skills, as well as to introduce them to the concepts and principles of computer science. In addition to traditional mathematics, primary school students in Poland are also introduced to computational thinking concepts. This includes basic programming concepts, such as sequencing, loops, and conditional statements, and computational problem-solving skills, such as decomposition and abstraction. (Mańka, 2017)

Many primary schools in Poland also incorporate computer science and programming into the curriculum, introducing students to block-based programming languages such as Scratch, which help to develop computational thinking skills. These skills are particularly important in today's digital age, as more and more aspects of our lives rely on technology. (K. Bobko, 2018)

Overall, the mathematics and computational thinking curriculum in Polish primary schools aims to provide students with a solid foundation in numeracy and problem-solving skills, as well as an introduction to the concepts and principles of computer science. This sets them up for success as they continue their education and enter the workforce.

4.4.3 Basic Principles of The Use of Robotics in Mathematics Education in Primary Schools

The use of robotics in mathematics education in primary schools can be an effective way to engage students in learning. Here are some basic principles to consider when using robotics in mathematics education in primary schools: (Lopez-Caudana, 2020)

- Start with age-appropriate robotics kits: Choose robotics kits that are designed for the age group of students. Some robotics kits are specifically designed for younger children,

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

with larger pieces that are easier to assemble. As students progress in age and ability, more complex kits can be introduced.

- Focus on problem-solving: Robotics can be a powerful tool for developing problem-solving skills. Encourage students to use the robots to solve mathematical problems, such as programming a robot to perform a specific task or navigate a maze.
- Incorporate hands-on activities: Students learn best by doing, so incorporate hands-on activities that allow them to interact with the robots and test their mathematical concepts.
- Use robotics to teach programming concepts: Robotics can also be used to teach programming concepts, such as sequencing, loops, and conditional statements.
- Provide opportunities for collaboration: Robotics projects can be collaborative and provide opportunities for students to work together and share their ideas. Encourage students to work in pairs or small groups to design and program their robots.
- Integrate robotics with other subjects: Robotics can be integrated with other subjects, such as science and technology.

Overall, the use of robotics in mathematics education in primary schools can be an effective way to engage students in learning and provide hands-on experiences that reinforce mathematical concepts. By following these basic principles, teacher can help students develop the skills and knowledge they need to succeed in a rapidly changing world. (S., 2021)

4.4.4. National and Private Initiatives for the Use of Robotics

In Poland, there are various national and private initiatives aimed at promoting the use of robotics in education, including in mathematics education in primary schools. Here are some examples:

The Robomaticon: It is probably the largest Polish robotic event. It takes place in the Main Building of the Warsaw University of Technology and every year more and more participants come to it. The main goal of the entire project is to promote and spread knowledge about robotics and all exact sciences and technologies. (Robomaticon, 2019)

Robotic Arena: an event organized by the scientific circle KoNaR from the Wrocław University of Technology. The event attracted such a large number of participants and

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

spectators that it was moved to the Centennial Hall - in 2020, the 12th edition of the competition took place. During this event, there are as many as 18 different competitions to choose from. These include the previously mentioned sumo-inspired robot fights, there is also a Freestyle or Micromouse category. (Robotic Arena, 2023)

Liga Robotów: National Robot League tournament. The aim of the initiative is to interest students in the subject of robotics for Science, Technology, Engineering, and Mathematics (STEM) education. (Liga robotów, 2023)

Private companies in Poland are also involved in promoting the use of robotics in education. For example TwojRobot.pl, Planeta Robotów (Planeta robotów, 2023), Mentor Systemy Audiowizualne (Edukacja STEAM (science, technology, engineering, art, maths), 2023).

Overall, there are various national and private initiatives in Poland aimed at promoting the use of robotics in education, including in mathematics education in primary schools. These initiatives provide valuable resources and support for educators and students, and help to develop the skills and knowledge needed for success in the 21st century.

4.4.5. Other Applications (Serious Computer Games, VR, AR, etc.)

There are a variety of computer applications and robotics tools that are used to enhance mathematics education for children in Poland. Here are some examples:

- Scratch: Scratch is a visual programming language that allows children to create interactive stories, games, and animations. It can also be used to teach math concepts such as geometry, angles, and coordinates. (Scratch, 2022)
- Matzoo: This is a portal with a lot of online games to help you learn math. It contains games suitable for students from all grades of elementary school. (Matzoo, 2010-2023)
- Code.org: Code.org offers a variety of courses and resources for teaching coding and computer science. Some of their courses include math concepts such as algebra, geometry, and data analysis. (Code.org, 2023)

These tools can be used in conjunction with traditional teaching methods to provide a more engaging and interactive learning experience for children. They can also help children develop problem-solving skills, logical thinking, and creativity.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

4.4. LATVIA (LATVIJAS UNIVERSITATE)

Authors

Ineta Helmane PhD

Linda Daniela PhD

4.4.1. General Overview

Robotics in education includes different applications of robots in teaching and learning, such as using robots as a support device (communication, motivating students, etc.), replacing a teacher at one stage of education with a robotic device (reading texts, etc.). However, there is still a lack of a clear definition of the purpose of introducing robots in education (Scaradozzi et al., 2019). Educational robotics aims to improve the human learning experience, where pedagogical and technological aspects are essential. It involves introducing, developing, selecting appropriate activities, tools and technologies with robots, and activities are pedagogically valid, including appropriate strategies (Angel-Fernandez, Vincze, 2018).

There are two basic types of educational robots, based on the ideas of S. Papert:

- Build Bots, which students construct before use, e.g. LEGO WeDo, LEGO Mindstorms EV3
- Ready-made User Bots - which can be taken out of the packaging and used immediately, e.g. Bee-Bot, Blue-Bot, Turtle (Catlin et al., 2019).

Robotics applications focus on ideas and techniques that promote robotics and coding, multidisciplinary STEM learning that can help students develop strong 21st century problem-solving skills (Marín-Marín et al., 2021) Educational robotics can impact on student learning, especially in STEM (science, technology, engineering and mathematics) fields (Castro et al., 2018). Educational Robotics aims to teach science, technology, engineering and mathematics through activities using robots, their sensors and their programming. Learning aim also include arts and humanities education, in which STEM becomes STEAM (Benitti, 2012). New methodologies that use and integrate science, technology, engineering, arts and mathematics (STEAM) in education have been rapidly introduced and often used in recent years and have emerged as a pedagogical alternative that provides a more holistic and

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

engaging education to enhance students' progress in different skills (Leoste, Heidmets, 2019), for instance, designe thinking, problem solving.

Integrating robotics-based activities into classroom learning enables diverse practice, encourages students to collaborate and allows them to reflect on their learning (You, Chacko, 2021). Integrating educational robotics into the educational process provides opportunities for students:

- Improve problem-solving skills by making complicated concepts easier to understand, research and make decisions.
- Increase self-efficacy: the natural manageability of the robot encourages experimentation, discovery and rejection, and therefore increases the learner's self-confidence, as they have the feeling that they are in control of the machine. It also strengthens pupils' critical thinking.
- Improve algorithmic thinking: pupils learn algorithmic thinking to decompose a large problem into smaller ones and then solve it. They learn to focus on important information and reject irrelevant information.
- Increase creativity by learning with knowledge in a more playful way. Learning turns into a fun activity and becomes more attractive and interesting for the learner (Evripidou et al., 2020).

Educational robotics promotes:

Teamwork: promotes socialisation and cooperation, by coordinating and pooling knowledge/skills, students will solve problems.

- Leadership and confidence: confidence in oneself and own abilities increases when taking on more difficult challenges. This self-esteem is enhanced by tolerance of disappointment when they do not do what is asked of them the first time.
- Entrepreneurship: students develop new skills based on experimentation and try/mistake. This awakens in them the desire to innovate, to think autonomously and thus to carry out their own projects.
- Logical thinking: robotics promotes logic and reasoning, so it is indirectly useful for working on philosophical thinking. It is a process in which analytical thinking can be improved through numerical calculations and logic programming schemes.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

- Creativity: imagination is always present as pupils have to design different models, robots, constructions.
- Curiosity: faced with a traditional repeating system, the student is the central figure as he has to produce the material using his own resources. Curiosity to discover something new increases their learning capacity.
- Concentration: works well with the most restless student who find it difficult to concentrate.
- Mathematics: improving problem solving, mathematical operations and reasoning (Amo et al., 2021).

Early learning of educational robotics helps reduce the gender gap in science and engineering, improves children's self-efficacy and confidence to invent new things (Zviel-Girshin et al., 2000).

4.4.2. Mathematics and Computational Thinking

Definitions of Computational Thinking:
- Thinking that solves problems in computer science and that requires abstract thinking; related to the ability to solve problems in computer science (Papert, 1980).
- Thinking processes involved in formulating problems and their solutions so that they can be represented in a form that can be implemented by a human or a computer (Wing, 2019).
- A set of skills that connect basic cognitive skills involved in complex tasks such as abstraction, computational thinking and data representation (Brennan, Resnick, 2012).
- A way of finding solutions by clearly defining the steps (Csizmadia et al., 2015).

Computational Thinking contains key principles:
- Understanding the interaction between computers and people;
- The ability to create algorithms to solve problems;
- Abstraction and the skills to find and use information;
- Problem analysis: possible solutions and prediction of other problems;
- Communication: be able to explain problems, provide possible solutions;
- Teamwork: actively collaborating with others to solve problems (Papert, 1996).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Algorithm(s) - used for planning and designing simple actions to solve problems (Yongheng et al., 2020; Selby, Woollard, 2013). Computational Thinking Educational Policy Initiatives (CTEPI)) have developed particularly rapidly since 2006 (Hsu et al., 2019). Algorithms do not depend only on the programming language used. Each algorithm can be expressed in different programming languages and on different devices (computer, tablet, smartphone, etc.). For this reason, algorithm design is the core of computer science. Algorithm development is a complex intellectual process, much more difficult than converting an algorithm into a program (Angeli, Giannakos, 2020).

Computational Thinking stages:

- Abstraction; In the context of educational robotics environments, abstraction occurs when students design robots with a limited response to conditions that might arise in reality. During the abstraction phase, students should consider different ways to make their robots interact with the real world; they should also consider abstracting the input and output of their program
- Automation; In the context of educational robotics environments, abstraction occurs when students design robots with a limited response to conditions that might arise in reality. During the abstraction phase, students should consider different ways to make their robots interact with the real world; they should also consider abstracting the input and output of their program
- Analysis (Qu, Fok, 2021).

The main essence of Computational Thinking is the ability to think like a computer scientist when faced with a problem (Labusch et al., 2019). It can be integrated into any life situation, as a step-by-step, logical way of solving problems, which is why its importance is particularly emphasised and why it is recommended, age-appropriately, from pre-school onwards. Computational Thinking is recognised as an essential component of student success in the digital age. Many researchers argue that integrating Computational Thinking into the core curriculum is the best way to ensure that all students have access to Computational Thinking. However, similar to what has already been described for robotics, the Computational Thinking community lacks a coherent conceptualisation to facilitate this integration, and there are authors who point to the fact that too little effort has been made

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

to critically analyse and synthesise research findings on the integration of Computational Thinking content into the curriculum (Kite et al., 2021).

Educational robotics and robotics curricula can promote computational thinking (Bers, Flannery, Kazakoff & Sullivan, 2014; Chen, Shen, Barth-Cohen, Jiang, Huang & Eltoukhy, 2017; Leonard, Buss, Gamboa, Mitchell, Fashola, Hubert & Almughyirah, 2016), improve motivation (Gomoll, Hmelo-Silver, Šabanović & Francisco, 2016; Master, Cheryan, Moscatelli & Meltzoff, 2017), enhance collaborations (Hwang & Wu, 2014; Menex, Higashi, Schunn & Baehr, 2017). Robotics is an powerful tool for hands-on practice for both robotics itself and general content in science, technology, engineering, and mathematics (STEM) (Gomoll et al., 2016).

Techniques for learning Computational Thinking by using:

- coding toys (Code & Go robotpeles, Cubetto, KIBO u.c.);
- robot kits (Wonder Workshops roboti, Dash & Dot, LEGO® Mindstorms EV3, LEGO® WeDo 2.0 kit u.c.);
- board games;
- augmented reality tools;
- applications/websites for developing programming concepts;
- animation / game development tools (Ching et al., 2018).

4.4.3 Basic Principles of The Use of Robotics in Mathematics Education in Primary Schools

In the educational environment, the analysis of technology-enriched learning has several directions, one of which is: the pedagogical conditions for the use of technological solutions in order to enhance students' learning from the perspective of learning outcomes (Daniela, 2018). Learning mathematics is not only facilitated by robotics, but the teacher, the activity and the learning situation play a key element in mathematics education (Zhong, Xia, 2020). Robots can be used for a number of purposes, from simple tools that can be programmed to behave in a certain way, to peer-to-peer interactions for collaborative learning, coding, design, maths and physics, and can be integrated with other areas of knowledge and tenhance the development of creativity (Daniela, 2022). Educational robotics can contribute

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

to the development of transversal skills such as communication and cooperation (Vitanza et al., 2019)

Educational robotics is useful in mathematics, also in other fields such as science, engineering and technology (Felicia, Sharif, 2014). Educational robotics activities are developed in a multidimensional problem space, requiring the integration of activities such as programming, building and environmental aspects. When learning robotics, students have the opportunity to take on roles in the group that are consistent with these multiple dimensions (e.g. programmer, builder and analyst). Group roles are an important element in all areas of learning, but especially in computer-based collaborative learning environments, as roles help to regulate group activity and learning (Keith et al., 2019). Robotics is recommended to be learned in pairs or groups rather than individually on the reason that pair learning in robotics education is obtained from pair programming and is influenced by many factors such as friend support, communication, cooperation in correcting mistakes of other group members (Zhong, Wang, 2021). Students use educational robotics to make positive changes in their personal development (Felicia, Sharif, 2014).

Cooperative learning is a widely used model for implementing robotics education. There are many studies investigating cooperative learning in various robotics activities. There are no statistically significant differences between pairs and no significant differences in learning outcomes between pairs with different learning styles (Zhong, Wang, 2021). However, there are risks associated with dividing students' work into pairs or groups:

- The "free rider" problem; there is a risk that there will be a student who will not participate in the process, who will "get off" at the expense of another who knows and understands what needs to be done;
- Conflict of interest; there may be a difference of opinion on how best/successfully to do the task;
- Fixed roles; there is a possibility that roles are assigned and each student does not develop himself/herself, but stays in place in what he/she knows well;
- Group thinking; none of the students go too deep because they expect someone else to do the task for them, as a result none of the students learn and the task is not completed (Konijn, Hoorn, 2020).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Teachers should motivate pupils to take an active part in the educational process. Teachers should recognize the potential of educational robotics in mathematics education (Shih et al. , 2012; Keren, Fridin, 2014). Educational robotics can be used for different purpose:

1. as a teaching tool, pedagogical methods where the robot is used as an ICT instrument/tool to achieve a aim and learning outcomes, for instance, in mathematics
2. as a cognitive, educational object, where robotics is just an additional subject with its own curriculum, and the student learns and understands the concept of robotics, the technical knowledge of how it works, how it is programmed and how it can be controlled;
3. as social robots, where they interact naturally with humans and behave in ways similar to human traits;
4. as a valuable tool that can help students develop cognitive and social skills (Angel-Fernandez, Vincze, 2018).

Characterisically, the most commonly used and effective teaching methods in the context of educational robotics:

- project-based, challenge-based, competency-based learning;
- problem solving, collaboration;.
- discovery, adventure;.
- simulations (Amo et al., 2020)

Educational robotics integrates learning and play, making education a joyful process. Learning is simpler, much more timely and effective when it is accompanied by play. Robotics is an educational resource that stimulates students' interest and curiosity through enjoyable activities. (Eguchi, 2010).

4.4.4. National and Private Initiatives for the Use of Robotics

From 1st September of the school year 2022/2023, the new education standards and curricula established by the Skola2030 project (Skola2030) has been implemented in schools. The curriculum standard includes a new subject - informatics. Informatics is integrated into other subjects from 1st to 3rd grade, such as art, social studies, mathematics. For example, in mathematics lessons in Grade 1, students learn linear algorithms in the topic "How to say and show: how many, where, who?". In Grade 4, informatics is a separate subject.

Informatics subject mainly includes computer literacy, computational thinking. In computer science, about a third of the teaching time is devoted to programming. Based on the school's facilities, teachers may choose to teach a graphical programming language and/or robotics.

The STEAM Masterminds project at the University of Latvia is an example of how mathematics, robotics (programming) and science are interlinked. This project developed curriculum for students in grades 4-6 (France, Bertule, 2019). Pupils learn the topic from different angles and the knowledge they acquire in mathematics lessons is applied in robotics and/or science. All the lessons in the module are interlinked. For example, in the "Car racing" module in science lessons, students build simple balloon-powered cars; students are using the knowledge from mathematics lessons. In programming lessons, pupils create a car racing game in Scratch or build racing robots - they have to program a Lego EV3 robot to drive around a track.

There are private initiatives for robotics such as LearnIT, AlfaRobot, RoboScientists, RoboHub and many others, most of which provide extra-curricular activities for students to build on and deepen the knowledge they have acquired. Currently, robotics lessons are about improving maths skills and knowledge, not the other way around, and it is important to mention that in most cases these lessons are not free.

According to data collected by LETERA (Latvian Electrical Engineering and Electronics Industry Association), there are more than 60 interest education institutions across Latvia offering robotics and electronics-related classes to children of different ages. Most of the classes are concentrated in Riga, but such classes are also available in other parts of Latvia. The red dots in the figure represent the official educational institutions (mostly electronics and technology-related secondary schools, technical colleges, also universities), while the grey dots represent all providers of education of interest. It should also be noted that at least some of the providers have classes not only in one location but also in schools, kindergartens, youth centres, etc.; robotics clubs are now available all over Latvia in schools, kindergartens and in institutions of interest (LETERA, 2019).

One of the first pioneers of the robotics movement was Agris Nikitenko, head of the RTU Robotics Club, who created the first robot in Latvia, as well as a technique that helps in

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

feeding livestock (a feed feeder). In the RTU Robotics Club, he not only runs clubs where students are taught how to build robots, how to program, but also organises Robotics Championships. One of the best attended championships is the "Solar Cup" organised by the Institute of Physics of the University of Latvia, where robots and other solar-powered devices compete. Robotics championships are now popular all over the world, with students from Latvia participating with great success. In Latvia, robotics classes are available as an interest group. In Latvia, one of the companies that has been distributing robotics equipment for education for more than 10 years is Robot-Nest, which sells, for example, Lego Mindstorm, Makeblock, as well as simpler programmable robots - Sphero balls.

4.4.5. Other Applications (Serious Computer Games, VR, AR, etc.)

The most popular sites for interactive material are: www.smartboard.lv - a company that offers modern interactive whiteboards and various other up-to-date technologies such as interactive tables, student response voting systems, wireless tablets, data document cameras, conference management software, etc. The company's website offers a variety of interactive learning materials for mathematics (MM; Smartboard). www.activboard.lv - various digital resources for mathematics, as well as sample digital worksheets from Lielvārds. www.skolotajs.lv - all materials on this site are created and contributed by teachers who are willing to share their positive experiences. The site is not as active now, but it still contains very interesting and useful exercises, games, presentations and other activities. http://www.dzm.lu.lv - 3 years of rich learning material to help you learn new topics, reinforce what you already know and broaden your horizons. The website offers learning materials for both teachers working in the classroom and students learning independently. ActivInspire is required to use the learning materials on your computer. The materials are designed to provide students with personally relevant, real-life learning content (DM and MM; dzm.lu)

Materials could be used in education process:

https://www.roadgames.com/lv

https://maciunmacies.valoda.lv/

https://drossinternets.lv/lv/info/izglitojosas-spelesuzdevumi

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

http://www.cirkulis.lv/matematika/

https://macibas.e-skola.lv/

https://www.uzdevumi.lv

https://www.e-klase.lv/

https://www.skola2030.lv

https://soma.lv

Studies in several European countries have shown that a significant percentage of children aged 5-7 already use technology for at least 2 hours a day. In the UK, 95% of 5-7 year olds use technology in their daily lives (mostly touchscreen tablets) and 35% have their own touchscreen tablets. The majority (71%) of children use YouTube to watch animated films and fun videos (Ofcom, 2017). Technology use is also high in Latvia. Almost one in two babies (47%) use technology by the age of 2. By contrast, between the ages of three and six, mobile devices and other technologies are used by 89% of children (Dardedze, 2016)

BLENDED LEARNING APPROACH & FLIPPED LEARNING

5.1. ITALY (SCUOLA DI ROBOTICA)

Authors:

Filippo Bogliolo

Emanuele Micheli

5.1.1. Blended Learning Approach (Theoretical Knowledge)

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 centres, 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

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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 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 theorised 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 artefacts, 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

5.1.2. Blended Learning Practices in Primary School Mathematics Education (in your country)

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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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.

5.1.3. Flipped Learning (Theoretical Knowledge)

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 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

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

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.

5.1.4. Flipped Learning Practices in Higher Education Institutions (in your country)

Flipped classroom methodology is an innovative approach to teaching that is gaining popularity in secondary schools in Italy. In a flipped classroom, students are given the opportunity to learn the material outside of class, usually through video lectures, readings, or online resources. This frees up class time for more interactive and engaging activities, such as discussions, problem-solving, and group projects.

In a secondary school setting in Italy, the flipped classroom methodology can be implemented in several ways. One approach is to assign video lectures or readings to students as homework, and then use class time for hands-on activities that reinforce the concepts learned in the videos or readings. For example, a history teacher might assign a video lecture about the Roman Empire for students to watch at home, and then use class time for a debate or role-playing activity that explores the social and political structures of ancient Rome.

Another approach is to have students work on collaborative projects outside of class time, using online tools such as Google Docs or Slack to collaborate and communicate with their peers. This allows students to learn from each other and to develop important skills such as communication, collaboration, and problem-solving.

The benefits of the flipped classroom methodology in secondary schools in Italy are numerous. It allows for a more personalized learning experience, as students can work at their own pace and focus on the areas where they need the most support. It also fosters a more engaging and interactive learning environment, as students are encouraged to ask questions, explore ideas, and collaborate with their peers.

Co-funded by the European Union

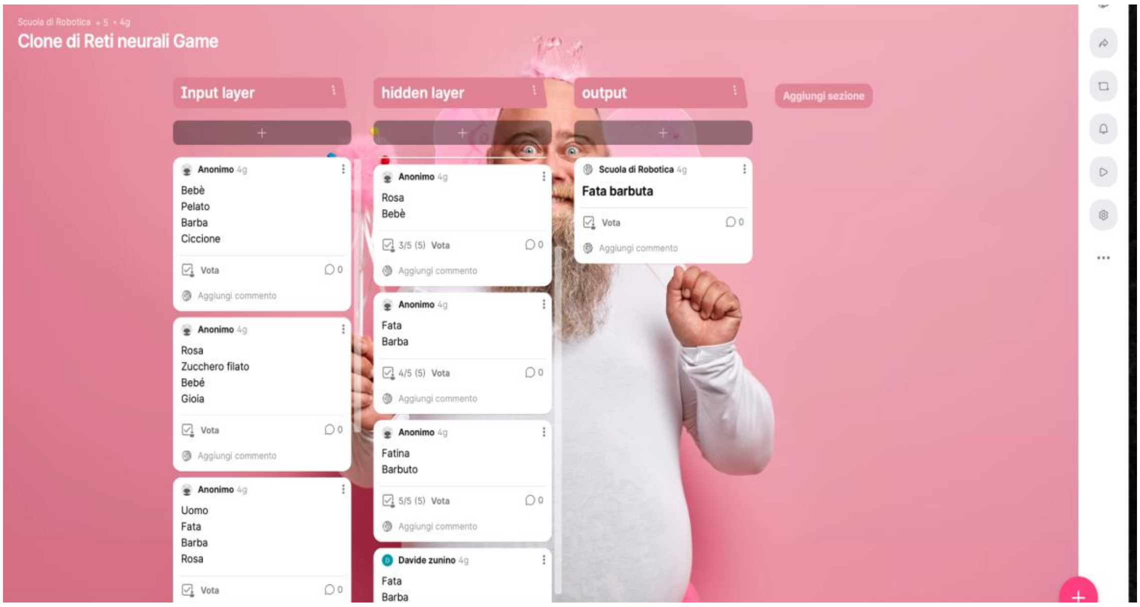
Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Overall, the flipped classroom methodology is a promising approach to teaching in secondary schools in Italy, and it has the potential to improve student engagement, learning outcomes, and overall academic success.

Scuola di Robotica is using in different ways with his schools networks the flipped classroom, usually using online software as Padlet and Google Jamboard.

In Math and in General in STEM Scuola di Robotica is following successfully different project and lessons.

For istance to teach Neural Network SdR is using an interactive padlet to introduce the mathematical concept and the "simulated" function of a Neural Network. In the picture you can see the neural newtork created with the methodology of flipped classroom and the use of a shared board as padlet.



The flipped classroom methodology can be particularly effective in the context of educational robotics in Italy. Here are some steps to implement the flipped classroom approach in educational robotics:

1. Create video tutorials: As a teacher, you can create video tutorials on various robotics concepts such as programming, sensor integration, and mechanics. You can use various online tools to create these tutorials, such as screen-casting software, online whiteboards, or presentation tools like Prezi or PowerPoint.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

2. Assign video tutorials as homework: Once you have created video tutorials, you can assign them as homework to students before class. You can also provide additional reading materials or online resources to supplement the video tutorials.
3. Provide hands-on activities in class: In the classroom, you can provide hands-on activities that reinforce the concepts learned in the video tutorials. For example, you can provide students with robotics kits or programmable robots to work with, and guide them through the process of building and programming robots.
4. Encourage collaboration and problem-solving: In the classroom, you can encourage collaboration among students by assigning group projects or problem-solving activities. You can also use online tools such as Google Docs or Slack to facilitate communication and collaboration outside of class.
5. Assess student learning: You can assess student learning through various methods such as quizzes, tests, or project evaluations. You can also use online tools such as Google Forms or Kahoot to create interactive assessments that engage students and provide instant feedback.

Implementing the flipped classroom methodology in educational robotics in Italy can provide students with a more engaging and interactive learning experience, while also promoting independent learning and critical thinking skills. Additionally, the hands-on activities and collaborative projects can help students develop important skills such as problem-solving, communication, and teamwork.

5.2. ROMANIA (UNIVERSITATEA LUCIAN BLAGA DIN SIBIU)

Authors:

Lia BOLOGA PhD

Diana BÎCLEA PhD

prof. Diana MIHĂESCU

5.2.1. Blended Learning Approach (Theoretical Knowledge)

Blended learning is a teaching approach that combines traditional face-to-face classes with online or/and digital learning. It combines face-to-face and technology-based learning and aims to optimize the strengths of both teaching formats.

The concept of blended learning has evolved over time, and it is difficult to trace its origins to a single author or source. However, here are some names of authors who have

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

contributed to the development of blended learning (B-Learning: Curriculum Design for Blended Learning (B-Learning, 2023):

- Charles Graham: Graham is a professor of instructional psychology and technology at Brigham Young University and is considered one of the pioneers of blended learning. He is the author of numerous publications on the topic and has developed several frameworks and models for designing effective blended learning environments.
- Clayton Christensen: Christensen is a professor at Harvard Business School, known for his work on disruptive innovation. He has written extensively on the potential of blended learning to transform education and advocates for a shift to more student-centered and personalized learning experiences.
- Michael Horn: Horn is an education strategist and co-founder of the Clayton Christensen Institute for Disruptive Innovation. He has written several books on blended learning, including Disrupting the Classroom: How Disruptive Innovation Will Change the Way the World Learns, which advocates for a more student-centered and technology-enhanced approach to education.
- Alison Rossett: Professor of Educational Technology at San Diego State University, Rossett is known for her work on technology-enhanced learning. She has written several books on the topic, including Blended Learning: Across Disciplines, Across Faculties, which provides a comprehensive overview of blended learning in higher education.

In blended learning, students typically attend regular classes but also use digital resources such as videos, online quizzes, and interactive simulations. These digital resources can be accessed outside of class or integrated into face-to-face classes.

Blended learning can take many forms, depending on the specific goals of the educational program and the needs of the learners. For example, in a flipped classroom model, students watch video lectures and complete online activities before class, where they can work on projects, ask questions and collaborate with peers. In another model, students can take traditional classes for part of the week and complete online classes the rest of the week (Bernard et al., 2014).

Blended learning can be beneficial in many ways. By combining the advantages of classroom instruction with the flexibility and interactivity of digital resources, blended learning can

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

provide a more personalized and engaging learning experience. It can also be more effective and less expensive than traditional classroom instruction because it allows teachers to reach larger audiences and requires fewer material resources.

There are several ways teachers can use blended learning to enhance instruction and improve student achievement. Here are some examples (Alammary et al., 2014; Bai et al., 2020; Bernard et al., 2014; Çakır & Bichelmeyer, 2016; Zainuddin et al., 2020): 1) flipped Classroom: Teachers can create videos or other multimedia content for students to review before class, allowing more time for hands-on activities and class discussions during face-to-face time; 2) online Discussion Forums: Teachers can use online discussion forums to encourage student participation and facilitate group discussions. This is especially helpful for shy or introverted students who are reluctant to attend class; 3) gamification: Teachers can incorporate game-based learning elements into their lessons to make learning more engaging and fun. This may include online quizzes, simulations and other interactive activities; 4) personalized Learning: Blended learning allows teachers to provide students with a more personalized learning experience by providing differentiated instruction and personalized feedback. Teachers can use online assessments and data analytics to track student progress and adjust their lessons accordingly.; 5) collaborative Learning: Teachers can use online tools to encourage collaboration and group work, even outside of the classroom. This can include online group projects, peer-reviewed events, and virtual study groups.; 6) flexible Learning: Blended learning can provide flexibility for students who have to miss class for personal or academic reasons. Online materials and resources are readily available, allowing students to catch up on missed assignments or review material as needed.

Overall, blended learning can provide teachers with a range of tools and strategies to enhance instruction, increase student engagement, and improve learning outcomes. It can be adapted to a variety of subjects and learning environments, making it an invaluable method for educators at all levels.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

5.2.2. Blended Learning Practices in Primary School Mathematics Education (in your country)

Blended learning practices in elementary mathematics in Romania are becoming more common as educators seek to increase student engagement and encourage more effective learning outcomes. Here are some examples of how Romania is using blended learning in primary school mathematics:

1. Online Resources: Teachers use a range of online resources, including videos, interactive simulations and online quizzes, to supplement their face-to-face lessons. Students can access these resources in and out of the classroom, allowing for greater flexibility and a personalized learning experience.
2. Interactive Whiteboards: Interactive whiteboards are used in many classrooms in Romania to enhance teacher-led instruction and encourage a more interactive and engaging learning experience. These whiteboards can display multimedia content, support real-time collaboration and provide instant feedback to students.
3. Gamification: Teachers incorporate game-based learning elements into their math lessons to make learning more engaging and fun. This can include online quizzes, games and other interactive activities that allow students to practice their skills in a fun and engaging way.
4. Collaborative Learning: Teachers use online tools to encourage collaboration and group work outside of the classroom. This can include online group projects, peer-reviewed events, and virtual study groups.
5. Personalized Learning: Blended learning allows teachers to provide students with a more personalized learning experience through differentiated instruction and personalized feedback. Teachers can use online assessments and data analytics to track student progress and adjust their lessons accordingly.

Overall, blended learning practices in primary mathematics in Romania help create a more engaging and effective learning environment for students. By integrating a range of digital resources and tools into the classroom, teachers can provide a more personal, interactive

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

and flexible learning experience that improves student achievement and prepares them for success in the 21st century.

In recent years, blended learning has gained attention and acceptance in Romania, especially in higher education. Here are some examples of blended study programs in Romania (Ganciu & Militaru, 2020; Muresanu & Buzoianu, 2020):

- POLITEHNICA University of Bucharest: The university has implemented blended learning across several of its courses, using a combination of online learning management systems, video conferencing tools and face-to-face teaching to provide students with a more flexible and personalized learning experience.
- Babes-Bolyai University: The university has incorporated blended learning into its medical education program, using online modules, virtual patient simulations and face-to-face clinical training to help students develop practical skills and competencies.
- SIVECO, Romania: The education technology company has developed a range of blended learning solutions for K-12 schools in Romania, including an online learning platform, interactive digital content, and teacher training resources.
- "Grigore Moisil" National University Timişoara: This high school implemented blended learning in several of its classes, using online quizzes, interactive whiteboards, and group projects to provide students with a more engaging and collaborative learning experience.

There is little data about using blended learning in primary school in Romania.

5.2.3. Flipped Learning (Theoretical Knowledge)

Flipped learning, also known as the flipped classroom model, is a teaching method that reverses the order of traditional classroom activities. In a flipped classroom, students are first exposed to new material or concepts outside of class, usually through online videos or readings. During class, students then engage in more interactive and collaborative activities such as discussions, group projects or problem-solving exercises that allow them to apply and deepen their understanding of the material.

Reverse learning models are often facilitated using technology, such as online learning management systems or video conferencing tools that allow students to access course

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

materials and communicate with teachers and classmates outside of class. Flipped learning can be applied to a wide range of subjects and grade levels from primary school to higher education (Strelan et al., 2020).

The benefits of flipped learning include increased student engagement, a more personalized learning experience, and improved retention of material. By allowing students to learn at their own pace and focus on areas where they need additional support, flipped learning can help encourage more effective and efficient learning outcomes. Additionally, by enabling more interactive and collaborative activities in the classroom, flipped learning can encourage more student engagement and promote the development of key 21st century skills such as critical thinking, problem solving, and communication.

Designing a course using the flipped learning model involves several important steps. Here are some general guidelines to get you started (Kızkapan, 2023; Shen & Chang, 2023; Stöhr et al., 2020): 1) Identify Learning Goals: Start by identifying the key concepts or skills you want your students to learn in your classroom. This allows you to determine which materials to assign for pre-study and which activities to include during class time.; 2) Create teaching materials: Create or curate teaching materials to help students learn them before class. This could be a video, reading material, podcast or interactive simulation. Make sure the material is engaging and accessible to all students, and make sure you provide clear instructions on what students should focus on or take notes on.; 3) Plan Lesson Activities: Design interactive and collaborative lesson activities that allow students to apply and deepen their understanding of the material. This may include group discussions, problem solving exercises, case studies or simulations. Make sure activities are aligned with learning objectives and provide opportunities for students to receive feedback and support from teachers and peers.; 4) Provide Feedback and Assessment: Regular feedback and assessment are provided throughout the course to help students monitor their progress and identify areas where they need additional support. This may include formative assessments, tests or short written assignments.; 5) Reflect and iterate: Finally, reflect on the effectiveness of the course and make changes as needed. Solicit feedback from students to identify areas where instruction can be improved and adjust class materials, class activities, and assessments as needed.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

5.2.4. Flipped Learning Practices in Higher Education Institutions (in your country)

In recent years, the flipped classroom model has attracted some attention and attention in Romania. Several universities and educational institutions in Romania have adopted the flipped classroom model in their courses with positive results, especially in increasing student engagement and encouraging more active learning (Caballano-Infantes et al., 2021; Fawzi, 2022). For example, the University of Bucharest has implemented the flipped classroom model in its English teaching program, and the Bucharest State School of Computer Science "Tudor Vianu" has adopted it in several of its courses. Additionally, some Romanian teachers have experimented with the flipped classroom model in their K-12 classrooms, especially in subjects such as math and science.

However, it is worth noting that the implementation and adoption of the flipped classroom model in Romania (as in any other country) may vary due to various factors such as teacher training, technology acquisition and cultural attitudes towards education. Overall, although the flipped classroom model may not be widespread in all classrooms in Romania, it certainly has potential for further development and adoption in the future.

5.3. TURKEY (CANAKKALE ONSEKIZ MART UNIVERSITESI)

Authors:

prof. dr Hasan Arslan

prof. dr M.Kaan Demir

Yasemin A. Öztürk PhD

prof. dr Muzaffer Özdemir

Tech. Kadir Tunçer

5.3.1. Blended Learning Approach (Theoretical Knowledge)

Technological developments have changed the concept of spatial and temporal distance. Thanks to technology, people who are not in the same place can have the same experiences jointly. In fact, people in different places have the opportunity to have common experiences in different time periods. This change has brought about a change in the learning-teaching processes in the field of education, as in every sector. Education-teaching activities designed

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

entirely face-to-face in the same place and in the same time period have begun to give way to synchronous and asynchronous education-teaching activities. In short, distance education activities have started to come to the fore. Since 2019, the Covid-19 epidemic all over the world has accelerated the developments in the field of distance education.

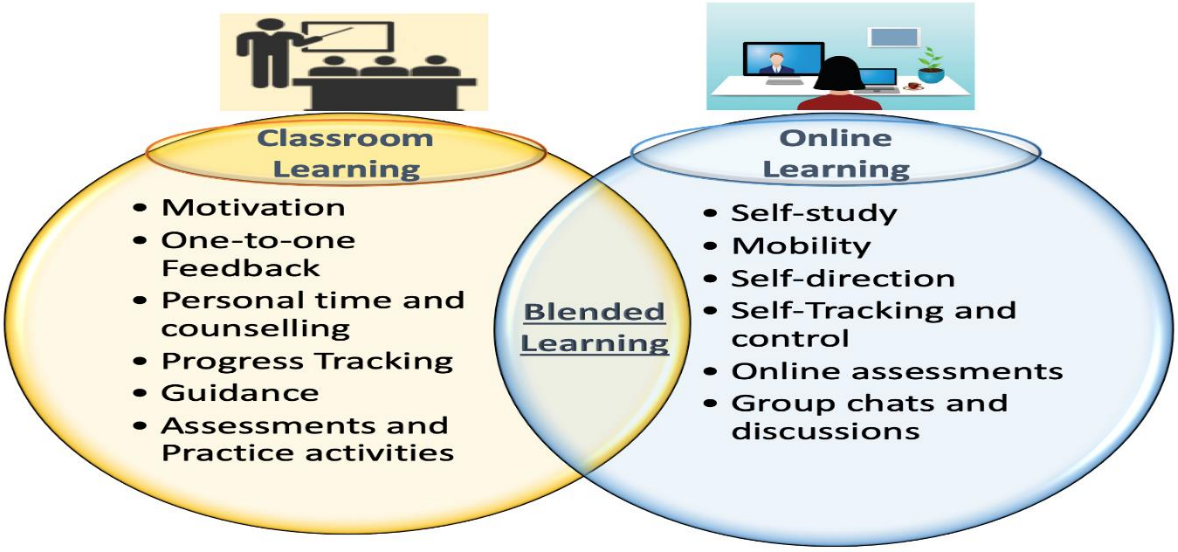
Distance education is a form of education in which face-to-face and other education methods can be used together, where the learner and trainer are physically in separate places, time and space flexibility is provided, and communication and interaction are established in online environments (Koç, 2021). Looking at the history of distance education; It can be said that it started with the education process by letter in the 1700s. People who do not have the opportunity for face-to-face education preferred to receive education through letters and to obtain their diplomas/certificates in this way. In later times, distance education continued on the basis of radio, TV, computer and internet. With the use of the Internet, the concept of "online learning" has emerged. It is not the same as online distance education, distance education includes online learning, it can be said that "online learning" is the "newest and most popular form" of distance education (Yıldırım, 2020). In Turkey, especially since the beginning of the 2000s, with the developments in the field of information and communication technologies (ICT), the educational opportunities offered by distance education have increased and the number of students benefiting from distance education has reached millions (Koç, 2021).

Distance education has many advantages such as improving the learner's sense of responsibility in the learning process, being learner-centered, providing equal opportunities, supporting individual teaching, and planning/controlling their own learning process by offering time and space flexibility in a systematic and planned way (Altun, 2020; Duman, 2020). However, when distance education is compared to face-to-face education; There are also disadvantages that cannot be ignored in terms of reducing communication and socialization, the existence of learning materials and instructional design deficiencies, and causing a lack of attention and motivation (Altun, 2020; Zembylas, Theodorou & Pavlakis, 2008). In this case, the need for an eclectic model arose by addressing the limitations and advantages of face-to-face and distance education. As a result of the researches, the blended learning model was put forward. The blended learning model can be expressed as a

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

combination of face-to-face and online learning experiences (Müller & Mildenberger, 2021; Williams, Bland & Christie, 2008).



Şekil 4: Blended learning combines the best of two learning approaches

Advantages of blended learning; It can be summarized as providing a learning environment suitable for individuals' own learning speed and style, enabling individuals to access different information and resources at a more affordable cost, providing rich learning materials, providing equal opportunities, providing the opportunity for individuals to control their own learning supervision, and reducing the cost of face-to-face education (Çırak Kurt, 2008). 2017; Rovai & Jordan, 2004; Sari, Rahayu, Apriliandari & Sulisworo, 2018; Utami, 2018). Wilson & Smilanich (2005) also stated the benefits of blended learning; It has been categorized in 5 different areas as reaching education in a wider area, ease of application, cost effectiveness, meeting different needs and advanced education (Dursun, 2018).

There are some elements that are essential for the effective implementation of blended learning: Identifying basic learning needs, considering different learning styles, determining learning objectives, considering the educational process and user-friendly demonstrations, and providing follow-up support (Thorne, 2003).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

5.3.2. Blended Learning Practices in Primary School Mathematics Education (in your country)

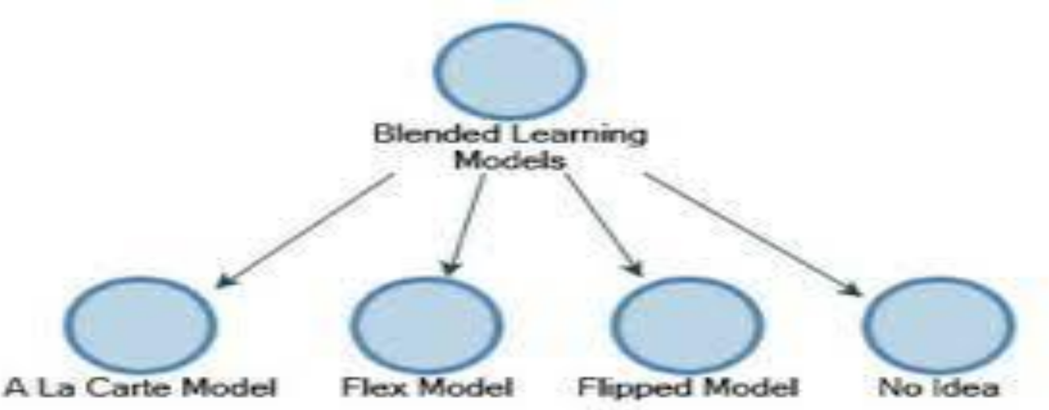
In order to achieve success in the field of mathematics; It can be used as a tool to increase students' interest in technology and their interest in learning mathematics. learning models are needed. In short; There is a need to use the blended learning model. The use of blended learning environments will bring success in the field of mathematics.

Blended education practices at the primary education level in Turkey appear in the form of parallel use of EBA and TRT Eba TV as face-to-face and distance education tools. Live lessons from all levels and classes are offered through EBA and Eba TV. EBA (Education Informatics Network) is a social educational electronic content network established by the Ministry of National Education in Turkey, where teachers can benefit from uploaded content and upload their own content. Students can benefit from many useful content such as EBA course, EBA test, EBA course online. In addition, live lessons were held by using zoom applications as a distance education tool during the COVID-19 process.

In addition, there are applications that provide many services such as lectures, materials, questions, measurement-evaluation studies, applied activities, interactive modules, which are used for an extra fee in Turkey. Some of them are: Morpa Campus (https://www.morpakampus.com.); Vitamin (https://www.vitaminegitim.com/), Okulistik (https://www.okulistik.com/), Derslink- (https://www.derslink.com/)

5.3.3. Flipped Learning (Theoretical Knowledge)

The models used in blended education are presented in Figure 5.



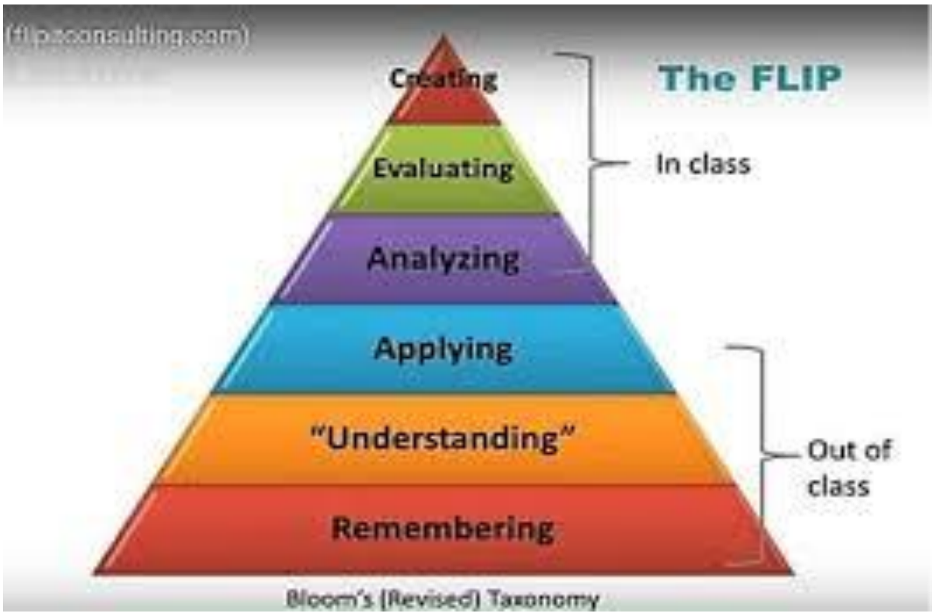
Şekil 5: Blended learning models (Bursa, 2023)

One of the models used in blended learning; It is flipped learning, which is preferred in many fields and education levels, in which the places of the course and post-lesson activities are changed, firstly, the students are prepared for the course content through distance education and then they are applied through face-to-face education (Ash, 2012). Flipped learning is suitable for educational approaches based on constructivist theory, student-centered and considering individual differences.

The flipped learning model is a model stated in Bloom's Taxonomy, where the first steps of learning, knowledge and comprehension, will be learned by the student outside the classroom, and in the classroom environment, it is a model that aims to take the student to high-level cognitive steps such as application, analysis and synthesis (Üstün & Çil, 2022). .

Co-funded by the European Union

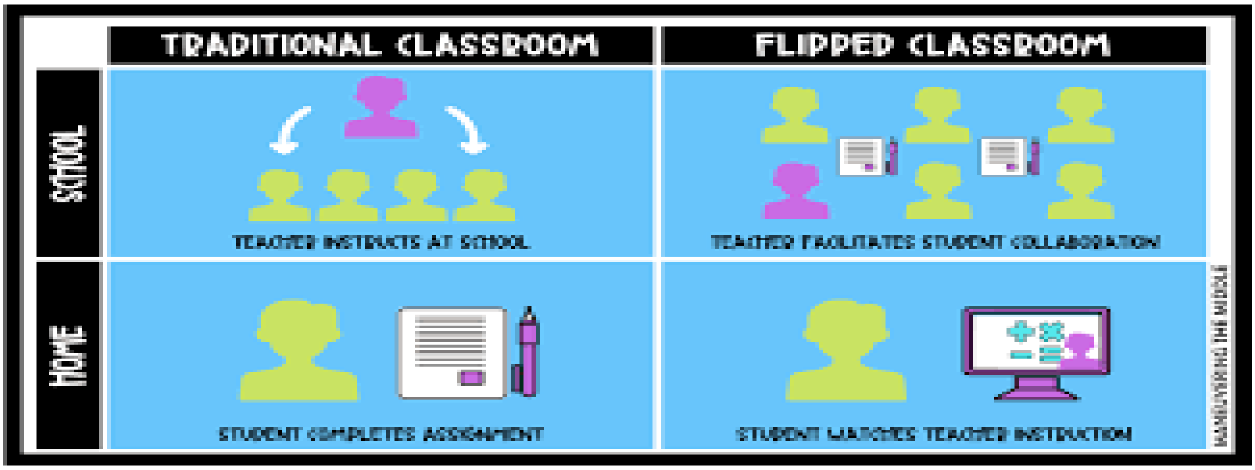
Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524



Şekil 6: Bloom's Taxonomy and Flipped Learning

Before the face-to-face lesson in flipped learning, students work with online activities and various learning materials such as e-books, presentations, video recordings, and participate in face-to-face training in the classroom to discuss the subject and to perform activities such as group work, projects, and homework. et al., 2022). Thus, with flipped learning; It is possible to take into account individual differences (especially learning speed, etc.), to carry out activities that are practical, active participation of students in the face-to-face education process, and deeper learning (Francis, 2017).

In Figure 7 below, traditional learning and Flipped learning are visually compared.



Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Figure 7. Comparison of traditional learning and Flipped learning (https://www.globsyn.edu.in/blog/how-is-flipped-classroom-flipping-the-role-of-traditional-classroom-pedagogy)

Flipped learning; Taking into account individual differences, increasing academic success, taking responsibility for learning, supporting effective time management, students being more active in face-to-face lessons due to the opportunity to prepare for the lesson, conducting the lessons without spatial and temporal restrictions, thanks to the distance education materials offered, the materials of the students before the lesson are many. It has many advantages such as having the opportunity to read/listen/watch once (Butt, 2014; Karaca & Ocak, 2017; Mason, Shuman, & Cook, 2013; Speller, 2015).

Below is the visual about the learning process of the flipped learning model in Figure 8.

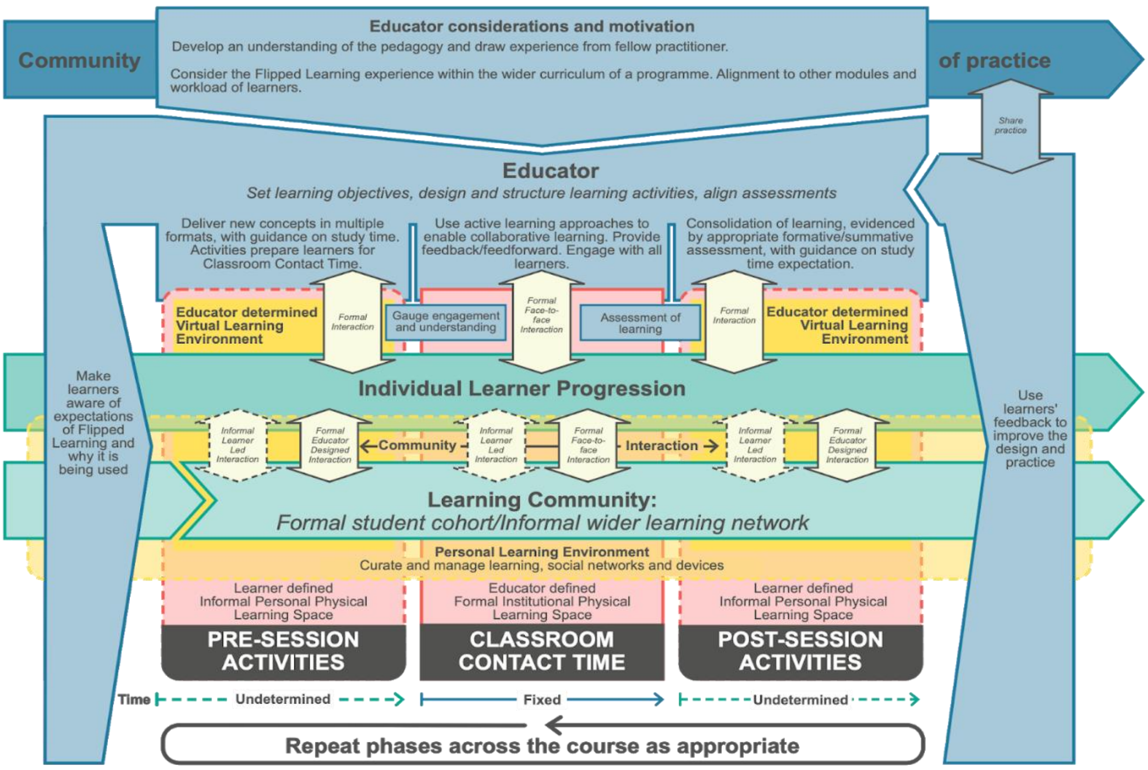


Figure 8. The Flipped Classroom Learning Ecology (https://www.mjmobbs.com/p/fcle.html)

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

5.3.4. Flipped Learning Practices in Higher Education Institutions (in your country)

As in the whole world, in Turkey, within the scope of emergency distance education applications during the Covid-19 pandemic process, as of the second semester of the 2019-2020 academic year, distance education has been switched from pre-school to higher education at all levels, instead of face-to-face education, and the use of online learning environments has become a necessity. . Universities continued the practice of distance education for about 1.5 years. Then, hybrid applications were started from the 2021-2022 academic year. These hybrid applications differed from institution to institution. Some universities offer some courses remotely and some courses face-to-face; some universities have included applications such that part of a course is distance education and part of it is face-to-face education. In this process, some of the faculty members upload the pre-lesson preparations as distance education to the related distance education system as documents, videos or audio lectures and apply the flipped learning model by asking the students to prepare for the process. Although the pandemic process is over, distance education applications in Turkey continue to be used in order to use time more effectively in the course preparation process.

A total of 181 studies, 72 of which were in 2022, as postgraduate thesis, were conducted between 2015 and 2022 on flipped learning in Turkey (https://tez.yok.gov.tr). The increase in the number of studies on flipped learning is an indication of the popularity of this subject in Turkey and the attempts to implement it.

5.4. POLAND (SPOŁECZNA AKADEMIA NAUK)

Author

Paweł Pełczyński PhD

5.4.1. Blended Learning Approach (Theoretical Knowledge)

Blended learning is an approach to education that combines traditional classroom teaching with online learning activities. It seeks to integrate the best of both worlds, leveraging the

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

benefits of face-to-face instruction and the flexibility and scalability of online learning. (Guide to Blended Learning. CHAPTER 1 : Blended Learning, 2017)

In a blended learning environment, students attend physical classes but also participate in online activities, such as video lectures, interactive modules, quizzes, and discussion forums. The online activities can be accessed anytime and anywhere, allowing students to learn at their own pace and review the material as needed.

Blended learning can be structured in various ways, depending on the goals, content, and audience of the course. Some common models include:

- Flipped classroom: In this model, students watch pre-recorded videos or read online materials before attending class, allowing the teacher to focus on interactive activities, problem-solving, and feedback.
- Station rotation: In this model, students rotate between different learning stations, such as online modules, small group discussions, and individual work, guided by the teacher or a facilitator.
- Flex model: In this model, students have more control over their learning path and pace, using online resources and personalized support from the teacher.
- Online lab: In this model, students attend physical classes but also have access to online tools and resources, such as simulations, virtual labs, and multimedia presentations.

Blended learning has several benefits, such as increasing student engagement, providing more personalized learning, allowing for more flexibility and scalability, and enhancing access to educational resources. However, it also requires careful planning, effective communication, and appropriate technology infrastructure and support to be successful.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

5.4.2. Blended Learning Practices in Primary School Mathematics Education (in your country)

Blended learning practices in primary school mathematics education in Poland started as a result of COVID19 pandemic restrictions. They take various forms. Here are some examples:

Using online platforms and resources: Teachers use various online platforms, such as Moodle, to share materials, assignments, and feedback with students. They also use online resources, such as Khan Academy, to provide interactive activities, games, and quizzes to reinforce math concepts.

Interactive whiteboards and tablets: Teachers sometimes use interactive whiteboards or tablets to enhance their classroom teaching, allowing students to interact with math concepts in a more visual and hands-on way.

Gamification and project-based learning: Teachers can use gamification and project-based learning to motivate students and engage them in math activities. (Monika Wiśniowska, 2023)

These blended learning practices can enhance primary school mathematics education in Poland by providing more personalized and interactive learning experiences, increasing students' motivation and engagement, and improving their math skills and competencies. However, they require appropriate teacher training, technological infrastructure, and pedagogical support to be effective.

5.4.3. Flipped Learning (Theoretical Knowledge)

Flipped learning is an instructional strategy where traditional teaching methods are inverted, and students learn new content outside of class time through pre-recorded lectures, readings, or other materials. This allows for more time during class to be spent on hands-on activities, group work, and discussion, allowing for a more interactive and engaging learning experience. (Peer, 2018)

In a flipped classroom, students take responsibility for their learning and work at their own pace, while the teacher acts as a facilitator, providing support and guidance when needed. This approach to learning has been found to be effective in improving student engagement,

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

motivation, and performance, as well as providing more personalized learning experiences. (Sevillano-Monje, 2022)

5.4.4. Flipped Learning Practices in Higher Education Institutions (in your country)

There are several examples of flipped learning practices in higher education institutions in Poland.

Lodz University of Technology is implementing a pilot project called "Reverse Education". It involves the implementation of active learning methods and effective tools for assessing learning outcomes. (Flipped Classroom, 2022)

Another example is a teaching experiment carried out in Poland and Ukraine. The participants in this study were students with comparable level of basic skills in MS Office in the Polish University of Silesia in Katowice and two Ukrainian universities: Borys Grinchenko Kiyv University and National University of Life and Environmental Sciences of Ukraine. Student requirements analysis was carried out and a module “Information technology” was designed for the students for studying with the use of flipped learning. (Olena Kuzminska, 2017)

5.5. LATVIA (LATVIJAS UNIVERSITATE)

Authors

Ineta Helmane PhD

Linda Daniela PhD

5.5.1. Blended Learning Approach (Theoretical Knowledge)

Blended learning is the purposeful integration of learning experiences in the classroom through online learning experiences (Garrison, Kanuka, 2004), blended learning systems combine self-learning and computer-mediated learning (Graham, 2006). Combined learning involves combining two problem areas: education and educational technology (Chew, Jones, Turner, 2008). blended learning is a formal educational programme in which the student learns at least part of the content and delivery of learning online with some student control

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

over time, place, path and/or pace and at least part in a supervised location away from home (Staker, Hor, 2013)

Blended learning can be developed into a teaching method that combines the most effective face-to-face teaching methods and interactive online collaboration, both through a system that works in constant interaction and forms a holistic whole (Krasnova, 2015). Blended learning methods vary from direct instruction to interactive teaching in self-directed learning communities (Biechele, 2010).

Eksistē šādi jauktās apmācības scenāriji:

1. Face-to-face education, complemented by digital resources. Learners explore information in digital resources, extend their skills and competences through open-ended tasks and closed-ended tasks for which they receive direct feedback and use online grammars, dictionaries and matching programmes.

2. Face-to-face classes, supplemented by other online components, in particular through web-based communication tools. Students receive homework by email or on a learning platform. The experience that learners gain is not directly absorbed in the classroom, so learners do not see the integration of their online activities in the institution (Biechele, 2010).

3. The in-person component and the online component are evolving and linked in terms of content. For example, there is a virtual exchange of Group B with a partner group that is prepared and followed up in the face-to-face sessions and can provide information on the topics covered in the face-to-face sessions. However, learners organise the actual exchange independently outside the lessons. The regular face-to-face teaching parts no longer take place as such, instead course participants meet only every four weeks and work together on projects with self-learning materials and online during the rest of the time.

4. Only virtually guided in teaching and learning. Learners work with self-paced materials supported by the internet, but can be supervised by an online tutor. Learners attend a virtual classroom in a virtual world where they are supervised by a teacher, but can also interact with other virtual learners with whom they can work and learn in partner or group work. There may also be personal contact. (Biechele, 2010).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

In blended learning, 40-79% of education is delivered remotely. In such learning, technology is mainly used to record learning events, assign tasks and upload learning materials in the learning management system. When learning is combined online with face-to-face classes, it is called semi-hybrid learning (sometimes called flipped classroom) - 15-39% of the learning content is delivered online. If more than 80% of the learning content is online, it is considered online/remote learning (Boettcher, Conrad, 2016).

Benefits of blended learning:

- promotes students' responsibility for their own learning, self-directed learning;
- enables students to plan their own learning time and pace, and to understand the subject matter in greater depth;
- enables students to organise their own learning time and work;
- encourages the learner to analyse his/her cognitive strengths and weaknesses and adapt his/her learning accordingly;
- fosters cooperation between students and creates innovative learning methods;
- provides opportunities to engage in learning in different places and at different times, blurring the boundaries between learning and real life.
- provides additional motivation to learn at any place and at any time, making learning a part of everyday life, blurring the boundaries between learning and real life.
- the introduction of a blended learning model in the education system is not without its challenges and difficulties (Tucker, Wyco, Green, 2017).

5.5.2. Blended Learning Practices in Primary School Mathematics Education (in your country)

The increased digitalisation of education has been a key outcome of the Covid-19 pandemic in many OECD countries. At the primary level, Latvia has responded to the pandemic by improving the provision of digital tools in schools, distance learning, hybrid learning, in-service and pre-service teacher training on digital tools and digital learning for students. Moving forward, the development of e-learning tools and digital competences are key objectives in the Latvian Education Development Guidelines 2021-2027 (Izglītības un zinātnes ministrija, 2021). Coping with the effects of the Covid-19 pandemic has come at an

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

additional cost to education systems. Preliminary budget estimates for 2021 show a slight increase (in nominal terms by 1-5%) in the education budget at pre-primary to tertiary level in Latvia compared to 2020 (OECD, 2020).

In the project "Living with COVID-19: Assessment of the Corona Virus Crisis in Latvia and Proposals for Future Societal Resilience," supported by the Ministry of Education and Science of the Republic of Latvia, project no. VPP-COVID-2020/1-0013 analysed the positive and negative aspects of blended learning in Latvia and developed proposals for the successful implementation of blended learning in real life. Combined learning is a model that needs to be implemented in the aftermath of the COVID 19 pandemic. This can be done at several levels: national, municipal, educational institution, individual (RTA, LU, RSU, 2020).

The Initial Impact Assessment Report of the draft Cabinet of Ministers Regulation "Procedure for the Organisation and Implementation of Distance Learning" stresses that "it is important to distinguish between the crisis period, when face-to-face learning was not possible, and the post-crisis period, when it will be possible to choose which activities to use distance learning for, including various technology-based learning solutions to enhance the learning of learners, including students. In distance learning, it is important to set clear learning objectives, such as developing digital competences, fostering self-directed learning, taking responsibility for own work, etc., and the roles of those involved in the process." (Cabinet Regulation). In Latvia, the introduction of blended learning is not sufficiently supported, nor is this learning model well known to teachers, as face-to-face learning is the leading learning model in schools. It is also stressed that blended learning should not be introduced compulsorily, but on an as-needed basis, while providing methodological, technological and strategic support to teachers (EU, 2020).

School 2030 has set quality benchmarks for the blended learning model:

1. Reliable information on participation. Do students participate directly in the learning process? Face-to-face is the best way to see this, blended is also quite good. In a remote model there must be a system that captures this.
2. Objective summative assessment. Even in distance learning, some of the work has to be done at school to see that the student has actually done the work. Summative assessment is not particularly distinguished among others! 3.Reliable information on

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

pupils' well-being. In a distance learning model, teachers need to get more information about this. 4.Reliable information on technical support and IT systems (Skola 2030).

5.5.3. Flipped Learning (Theoretical Knowledge)

Flipped learning is one of the approaches to student-centred learning. The terms flipped classroom and flipped learning are used in the implementation of educational processes (Toivola, Silfverberg, 2014). Both flipped classroom and flipped learning "flip" traditional learning approaches. In a traditional learning approach, the teacher presents the new information during the lesson and the students practice their learning at their homework. Flipped learning is a form of learning organisation that switches between classwork and homework (Bergmann, Sams, 2012). Flipped classroo is used to refer to technical changes in the teaching process, while flipped learning is used to refer to changes not only in what teachers and students do in the classroom, but also in their beliefs about teaching and learning (Toivola, Silfverberg, 2014). Flipped classroom also includes changes to the learning process (Bergmann, Sams, 2012). Consequently, there is no strict distinction in the use of the two terms. In a flipped learning approach, the student learns the new information before the lesson (most often by watching a short video lecture) and works with the new information during the lesson. The flipped learning approach has no specific methodology and can be implemented in different ways, given that the focus of the lesson shifts from the teacher to the student and the learning process (Bergmann, Sams, 2012).

Table 1 Role distribution in traditional and "flipped" learning approaches (Kurvits, 2018)

	Traditional approach	Flipped learning approach
Student	The student is passive, without initiative or desire to learn independently. Works in a "listen, memorize, reproduce" pattern	Involving students in the learning process. Student is responsible for their own learning. Interaction with all participants in the learning process.
Teacher	The teacher transfers knowledge, maintains discipline and maintains order in the classroom.	The teacher constructs learning situations, promotes students' responsibility for learning, and fosters a trusting relationship with the class
Teaching/learning	In the classroom, students listen to the	Introduction to educational material (watching

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

process	teacher's explanations. Coming home after school, they do their homework, often unsuccessfully and without the opportunity to ask questions or get explanations.	a video, learning a paragraph, students working together via ICT) on a new topic, and in the classroom - problem-solving and applying knowledge and skills to a new situation.
Strategies	Information is directed from teacher to student	Students work together to discover new knowledge
ICT	Using technology and web tools for learning	Enriching working methods and forms through ICT

The flipped learning approach has several advantages:

1. The digital environment is easy for students to understand and use. Students see it as a natural way to get information.
2. Learning is flexible. Pupils can more easily catch up on content missed due to illness or other reasons. Pupils can learn more - the content they will need for future lessons.
3. Pupils learn to plan their time.
4. Students who have difficulty with the content can pause the video lecture, re-watch part or all of the video lecture (Bergmann, Sams, 2012).
5. the flipped learning model helps low-achieving pupils achieve more.
6. the teacher interacts more with pupils, for example by working individually with individual pupils or groups of pupils in the classroom, thus ensuring differentiation and a more individual approach for each pupil
7. the teacher is able to increase interaction between pupils.
8. differentiation of learning tasks according to the readiness level of the pupils is possible.
9. changing the form of lesson organisation helps to solve classroom management problems.
10. parents can see what it is that pupils need to learn. The learning process is more open/transparent (Bhagat, Chang, Chang, 2016)

The flipped learning approach also has drawbacks that need to be taken into account:

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

1. the teacher needs to make sure that all pupils have access to materials for working outside the classroom, e.g. access to a computer, the internet (Bergmann, Sams, 2012).
2. parental support is needed, especially when flipped learning is used for younger pupils. Parents need to accept that pupils use ICT outside the classroom and that pupils need to take time to prepare for the lesson (Creative Classroom Lab, 2012.).
3. If the student is not prepared for the lesson, he/she cannot participate fully in the lesson. There must be a system for dealing with such situations. For example, there may be two computers in the classroom that students can use to watch a video (Bergmann, Sams, 2012).
4. Students may initially lack the self-regulatory skills to learn independently (Lai, Hwang, 2016). A system needs to be put in place to help students plan their time, to help them learn, and to help them evaluate what they have learned.
5 Initially, the teacher needs to invest a lot of time in selecting or creating a base of materials for the student to work with outside the classroom. The materials should be of high quality, easy to understand and comprehend. Teachers can start by using materials created by other teachers before creating their own (Bergmann, Sams, 2012).

5.5.4. Flipped Learning Practices in Higher Education Institutions (in your country)

At the University of Latvia, as well as at other higher education institutions, there is a tendency to use the practice of flipped learning. Mostly lecturers provide students with the opportunity to get acquainted with materials in MOODLE environment. It is important to give instructions and guidelines so that students can accurately perform activities in the learning process. For example, before the class, the student should read and study the theory of the laboratory work in it. The student must also complete an online test with at least 80% correct answers. During the practical exercise, the student can ask for help. After the practical assessment has been completed and the report written, the student and the professor have a dialogue about the laboratory work. During the discussion, the report is divided into stages and each stage is discussed, as well as problems encountered, theoretical issues and many other aspects. As a result, students tend to have a more complete knowledge of the theory covered in the laboratory work and discussions than when attending classical lectures.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

The flipped learning approach has become popular because of the digital library developed by Khan Academy with the support of Microsoft. The digital library, available online at https://www.khanacademy.org, includes videos, explanations and tests on a variety of topics in different subjects for students from grades 1 to 12. This approach is also increasingly used as the internet, computers and tablets become more accessible to students (Hao, Lee, 2016). Last but not least, students also rate this teaching approach positively, describing it as useful and effective (Bergmann, Sams, 2012; Mok, 2014)

RECOMMENDATIONS

6.1. ITALY (SCUOLA DI ROBOTICA)

Authors:

Filippo Bogliolo

Emanuele Micheli

Here are some recommendations for how robots can be used in primary school mathematics education through a blended learning approach:

1. Integrate robotics into the curriculum: Robotics can be integrated into the primary school mathematics curriculum in various ways. For example, robots can be used to teach basic geometry concepts such as angles and shapes, or to help students visualize mathematical concepts such as fractions and decimals.

2. Use robots for hands-on learning: Robots can provide students with a hands-on learning experience, allowing them to apply mathematical concepts in a real-world context. For example, students can program robots to navigate a maze or perform a specific task, which requires them to use mathematical skills such as measurement, calculation, and problem-solving.

3. Use a blended learning approach: A blended learning approach can combine the benefits of both traditional classroom learning and online learning. Teachers can use online resources such as videos, interactive tutorials, and online quizzes to supplement the

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

classroom learning experience, while also providing students with opportunities to work with robots in the classroom.

4. Encourage collaboration and problem-solving: Using robots in mathematics education can also promote collaboration and problem-solving skills. Teachers can assign group projects or problem-solving activities that require students to work together to program robots to solve specific challenges.

5. Provide professional development for teachers: To effectively use robots in primary school mathematics education, teachers may need professional development and training on how to integrate robots into the curriculum and use them effectively in the classroom.

Overall, using robots in primary school mathematics education can enhance the learning experience for students and provide them with a more engaging and interactive way to learn mathematical concepts. A blended learning approach that combines traditional classroom learning with online resources and hands-on activities with robots can be particularly effective.

6.2. ROMANIA (UNIVERSITATEA LUCIAN BLAGA DIN SIBIU)

Authors:

Lecturer PhD Lia BOLOGA

Lecturer PhD Diana BÎCLEA

Prof. PhD Diana MIHĂESCU

Regardless of age and experience level, robots make learning more fun by combining abstract concepts with experiments and practical applications from the simplest to the most complex. These educational robots are specially designed to introduce students to science, physics, math, robotics and programming. Having robots in school provides an opportunity to spark a child's interest in a future subject at a young age. Young children can thus find a passion for robotics from an early age and want to continue it later in school. Regardless of a child's age or learning stage, using an educational robot has many advantages. From learning numbers and building vocabulary for toddlers to understanding how to program a robot to walk, there's an advantage for everyone.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

A recommendation is to use more teaching in the blended learning system and to integrate this, especially at the primary level. In this sense, the proposed project is welcome. Another recommendation is to find solutions for the flipped classroom, including the materials to be developed in this project can be used for the flipped classroom, especially in primary education. Another recommendation is that when changes are made at the level of school programs, especially for the disciplines in the "Mathematics and natural sciences" curriculum area, content should be suggested that includes robotics and the use of robots and applications in teaching, learning and evaluation.

6.3. TURKEY (CANAKKALE ONSEKIZ MART UNIVERSITESI)

Authors:

Hasan Arslan

M.Kaan Demir

Yasemin.A.Öztürk

Muzaffer Özdemir

Kadir Tunçer

- It should not be forgotten that the main reason for negative attitudes towards mathematics is to see mathematics as an abstract field, and robotic coding activities should be used as a tool for students to become active learners in order for children to embody mathematics.
- An interdisciplinary approach should be adopted by considering the developmental characteristics of children in the design of robotic coding activities in primary school mathematics education.
- It should not be forgotten that the real target in the use of robotic coding activities in primary school mathematics education is mathematics achievements, and robotic coding skills should not come to the fore.
- Considering that robotic coding is related to algorithmic thinking skills; Cognitive thinking skills, readiness levels and individual differences in this regard should be taken into account in designing and hiring activities. Otherwise, robotic coding-based activities may make learning mathematics even more difficult for students.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

- In order for robotic coding to be used effectively by classroom teachers in mathematics education, teacher competencies should be taken into account, and optional courses should be included in both pre-service teacher education and extra training in in-service teacher education.
- Researchers from the fields of classroom teaching and information technologies regarding the application of robotic coding in the field of mathematics education should be supported in developing applied, innovative projects with an interdisciplinary approach.

6.4. POLAND (SPOŁECZNA AKADEMIA NAUK)

Author

Paweł Pełczyński PhD

By integrating robots into primary school mathematics education through a blended learning approach, students can benefit from a more engaging, personalized, and interactive learning experience. Robots can be used in primary school mathematics education through a blended learning approach in the following ways:

- Personalized learning: Robots can be used to provide personalized learning experiences for students. By analyzing their progress and performance, the robots can adapt to the needs of each student, providing additional support or challenges as needed.
- Collaborative learning: Robots can facilitate collaborative learning by encouraging students to work together on math problems.
- Feedback and assessment: Robots can provide instant feedback to students, letting them know if they have solved a problem correctly or incorrectly. Additionally, robots can collect data on students' progress and provide feedback to teachers on areas where students may be struggling.
- Gamification: Robots can be used to gamify mathematical concepts, making them more engaging and interactive for young learners. For example, robots can be programmed to play math games with students, such as quizzes or puzzles, where they have to solve problems to win.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

6.5. LATVIA (LATVIJAS UNIVERSITATE)

Authors

Ineta Helmane PhD

Linda Daniela PhD

Students use STEAM skills in a variety of daily activities. Pupils explore and develop skills when they play. Pupils explore, discover and solve problems when they investigate their surroundings. Pupils try to find out how the world works. STEAM is everywhere:

S – scientists, learn from others, observe what others do and learn by trying to imitate what they see.

T - Technology, which includes simple tools, supports pupils' cognitive development, such as wheels, levers and scissors.

E - 'Engineering', like using materials, building, designing, understanding how things work.

A - Arts, such as drawing, painting, music.

M - Mathematics, as in numbers, patterns, geometry (Chaldi, Mantzanidou, 2021).

Approaches for robotics use in primary schools:

1. Subject-based. In this learning process, each lesson selects a topic to be taught and integrates the content of the lesson (information delivery, construction) around it. This lesson model is used in the author's research at the fieldwork site.

2. Project-based learning approach. In this approach, students work in groups and a real problem is posed for which they work together to find a solution. This learning approach requires long-term engagement and also takes place outside educational institutions.

3. Goal-oriented approach where children compete to find solutions to different problems. This learning approach also requires long-term engagement and takes place outside educational institutions. (Eguchi, 2010).

When learning algorithmic thinking through educational robotics, it is important to notice that:

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

- Understanding the differences between robotics in education and educational robotics is essential, as it is important for educators to consider the classification, application goals and pedagogical methods of educational robotics when choosing a type of educational robot.
- When creating teaching methodological materials, the first thing to do is to set the goal of introducing educational robotics into the teaching process in mathematics lessons. The learning outcomes of the curriculum should be clearly defined. Next, the teaching methods and pedagogical conditions for achieving the objective and the learning outcomes should be defined. The structure of the teaching module should then be established, with lessons divided into sub-topics, clearly indicating at which stages educational robotics is included in the teaching process.
- Computational thinking is about problem solving, logical thinking, human-computer interaction, including programming, and educational robotics is one of the best tools to develop it. The new and improved curriculum integrates it into computer science, mathematics, engineering, design and technology, as well as into the teaching materials developed by the author.
- The teacher's lesson plan - methodological material - is one of the most necessary components for a successful and complete lesson, probably due to the lack of experience of teachers in the field of educational robotics and its implementation in the teaching process (Veinberga, 2022).

Before implementing a flipped learning approach, the teacher should answer the following questions:

- What is the most effective use of lesson time?

- Which lesson is most suitable for the flipped classroom approach?

- Is the teacher willing to give more responsibility to the students?

- What will pupils do in lessons if they have acquired basic knowledge outside the classroom?

- How to change the classroom set-up?

- Should videos be made or other teachers'?

- How will pupils access electronic materials? Do all pupils have access to the internet?

- What software and devices are needed to create materials for students?

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

- Where to post videos (e.g. www.youtube.com)?

- How to make sure that students have watched/learned the material?

- What if the learner has not watched/learned the material?

- How to change the assessment of learning?

- How to explain changes in teaching to pupils, parents and school management? Flipped learning can be used in a variety of subjects, especially in knowledge-intensive subjects, to allow students to spend more time in lessons on meaningful higher-level tasks (Bergmann, 2013).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

REFERENCES

ITALY

Ashcraft M. (2002). Math Anxiety: Personal, Educational, and Cognitive Consequences. https://www.mccc.edu/~jenningh/Courses/documents/math_anxiety.pdf

Ashcraft M. H., Krause J.A.(2007). "Working memory, math performance, and math anxiety". Psychonomic Bulletin & Review, volume 14, pages243-248

Beilock, S., Willingham, D. T. (2014). "Math Anxiety: Can Teachers Help Students Reduce It? Ask the Cognitive Scientist". American Educator, v38 n2 p28-32, 43 Sum 2014

Free paper: https://files.eric.ed.gov/fulltext/EJ1043398.pdf

BRANCACCIO, Anna, et al. Matematica e Scienze più SMART per l'Insegnamento e l'Apprendimento. 2015.

D'AMORE, Bruno; FANDIÑO PINILLA, M. I. A proposito di "metodi di insegnamento" univoci. Errori pedagogici, epistemologici, didattici e semiotici delle metodologie univoche. La Vita Scolastica web, 2016.

Dowker, A., Sarkar A., and Chung Yen Looi C. Y. Mathematics Anxiety: What Have We Learned in 60 Years? Front Psychol. 2016; 7: 508, published online 2016 Apr 25

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4842756/

Faust M.W. (2010). Mathematics Anxiety Effects in Simple and Complex Addition. Analysis of physiological reactivity in mathematics anxiety.

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

Hembree R. (1990). The Nature, Effects, and Relief of Mathematics Anxiety. Journal for Research in Mathematics Education. Vol. 21, No. 1 (Jan., 1990),

https://www.jstor.org/stable/749455?read-now=1&seq=2#page_scan_tab_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. 22

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Kucian, K. et al (2018). “Relation Between Mathematical Performance, Math Anxiety, and Affective Priming in Children With and Without Developmental Dyscalculia”. In: Frontiers in Psychology, 26 Apr 2018, 9:263

Free paper: https://europepmc.org/article/PMC/5932531#B8

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.

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

NUNES, Terezinha. Development of maths capabilities and confidence in primary school. 2009.

OECD (2013). PISA 2012 Results: Ready to Learn: Students' Engagement, Drive and Self-Beliefs (Volume III). PISA, OECD Publishing; 10.1787/9789264201170

s://www.oecd-ilibrary.org/education/pisa-2012-results-ready-to-learn-volume-iii_9789264201170-en

Anxiety and Mathematics: An Update

Pizzie, R., Kraemer, D. J.M. /2017). Strategies for Remediating Anxiety in High School Math

Free preprint: https://psyarxiv.com/ye526/

Ramirez G., Shaw S., Maloney A.E. (2018). Math Anxiety: Past Research, Promising Interventions, and a New Interpretation Framework. April 2018 Educational Psychologist 53(2):1-20

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

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

Tobias S., Weissbrod, C. (1966). Overcoming Math Anxiety. Harvard Educational Review (1980) 50 (1): 63–70.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Young C.B., Wu S. S., Menon V. (2012). The Neurodevelopmental Basis of Math Anxiety. 2Psychological Science 23(5):492-501

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

ROMANIA

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Alammary, A., Sheard, J., & Carbone, A. (2014). Blended learning in higher education: Three different design approaches. Australasian Journal of Educational Technology, 30(4), 440–454. https://doi.org/10.14742/ajet.693

Bai, S., Hew, K. F., & Huang, B. (2020). Does gamification improve student learning outcome? Evidence from a meta-analysis and synthesis of qualitative data in educational contexts. Educational Research Review, 30. https://doi.org/10.1016/j.edurev.2020.100322

Bernard, R. M., Borokhovski, E., Schmid, R. F., Tamim, R. M., & Abrami, P. C. (2014). A meta-analysis of blended learning and technology use in higher education: From the general to the applied. Journal of Computing in Higher Education, 26(1), 87–122. https://doi.org/10.1007/s12528-013-9077-3

B-Learning: Curriculum Design for Blended Learning (B-Learning). (n.d.). Retrieved February 27, 2023, from https://innovative-teaching-award.ec.europa.eu/projects/b-learning-curriculum-design-blended-learning-b-learning_en

Baek, Y., Wang, S., Yang, D., Ching, Y.-H., Swanson, S. și Chittoori, B. (2019). Revisiting Second Graders' Robotics with an Understand/Use-Modify-Create (U2MC) Strategy. Journal European de Education STEM, 4 (1), 07. https://doi.org/10.20897/ejsteme/5772

Bellas, F., Salgado, M., Blanco, T. F., & Duro, R. J. (2019). Robotics in Primary School: A Realistic Mathematics Approach. In L. Daniela (Ed.). Smart Learning with Educational Robotics (pp. 149-182). Springer, Cham.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Benga, O., Ţincaş, I., & Visu-Petra, L (2010). Investigating the structure of anxiety symptoms among Romanian preschoolers using the Spence Preschool Anxiety Scales. Cognition, Brain, Behavior, 14(2).

Caballano-Infantes, E., Borrego, L. G., di Zeo-Sánchez, D. E., Sánchez-Núñez, P., Delgado-Martín, B., Sánchez-Gómez, C., Brichette-Mieg, I., Terrón-Bautista, J., & Marrero, A. D. (2021). Flıpped classroom research durıng Covıd-19 pandemıc: a scıentometrıc overvıew. EDULEARN21 Proceedings, 1, 9071–9078. https://doi.org/10.21125/EDULEARN.2021.1828

Çakır, H., & Bichelmeyer, B. A. (2016). Effects of teacher professional characteristics on student achievement: An investigation in blended learning environment with standards-based curriculum. Interactive Learning Environments, 24(1), 20–32. https://doi.org/10.1080/10494820.2013.817437

Demo, G. B., Marcianò, G., & Siega, S. (2008). Concrete Programming: Using Small Robots in Primary Schools. Eighth IEEE International Conference on Advanced Learning Technologies. doi:10.1109/icalt.2008.19

Fawzi, M. (n.d.). (2022). How to gamıfy the flıpped classroom to support Romanıan language learnıng?, pp. 301–310), Editura Eikon.

Ganciu, M.-R., & Militaru, G. (2020). Blended learnıng: adaptıng technology ın technıcal hıgher educatıon as a new approach - evıdence from Romanıa. INTED2020 Proceedings, 1, 5349–5356. https://doi.org/10.21125/INTED.2020.1443

Gasnaș, Ala. (2022). Informatics and the STEAM concept. Abordări inter/transdisciplinare în predarea științelor reale, (concept STEAM). Ediția a 2-a, 28-29 octombrie 2022, Chisinau. 2022, pp. 286-292.

Kızkapan, O. (2023). Student science teachers' research self-efficacy: does it develop in a flipped course and predict achievement? Interactive Learning Environments, 1–13. https://doi.org/10.1080/10494820.2022.2163262

Khasawneh, E., Gosling, C. & Williams, B. (2021). What impact does maths anxiety have on university students?. BMC Psychol 9, 37. https://doi.org/10.1186/s40359-021-00537-2

Li, Jie, Heng Luo, Leilei Zhao, Min Zhu, Lin Ma, and Xiaofang Liao. (2022). Promoting STEAM Education in Primary School through Cooperative Teaching: A Design-Based Research Study, Sustainability 14, no. 16: 10333. https://doi.org/10.3390/su141610333

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Muresanu, D., & Buzoianu, A. D. (2020). Moving Forward with Medical Education in Times of a Pandemic: Universities in Romania Double Down on Virtual and Blended Learning. Journal of Medicine and Life, 13(4), 439. https://doi.org/10.25122/JML-2020-1008

Vlada, M. (2003). Gândirea algoritmică - o filosofie modernă a matematicii si informaticii, CNIV-2003, Noi tehnologii de e-learning. Conferinţa Nationala de Învăţământ Virtual, Software educaţional. Editura Universităţii din Bucureşti.

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). TIMSS 2019 International Results in Mathematics and Science. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: https://timssandpirls.bc.edu/timss2019/international-results/

OECD (2016) PISA 2015 Results (Volume I): Excellence and Equity in Education, Paris:OECD Publishing. https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf

OECD (2013), PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy, PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264190511-en

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York: Basic Books, Inc., http://worrydream.com/refs/Papert%20-%20Mindstorms%201st%20ed.pdf .

Petruț, A. I., & Visu-Petra, L. (2020). Anxietatea faţă de matematică: Clarificări conceptuale şI psihometrice [Self-reported mathematics anxiety: Conceptual and psychometric considerations]. Revista de Psihologie, 66(3), 279–290. https://psycnet.apa.org/record/2021-31856-006

Sarkar, A., Dowker, A., Cohen, K.R. (2014). Cognitive Enhancement or Cognitive Cost: Trait-Specific Outcomes of Brain Stimulation in the Case of Mathematics Anxiety, Journal of Neuroscience , 34 (50) p. 16605-16610; DOI: https://doi.org/10.1523/JNEUROSCI.3129-14.2014

Shen, D., & Chang, C.-S. (2023). Implementation of the flipped classroom approach for promoting college students' deeper learning. Educational Technology Research and Development. https://doi.org/10.1007/S11423-023-10186-4

Stöhr, C., Demazière, C., & Adawi, T. (2020). The polarizing effect of the online flipped classroom. Computers and Education, 147. https://doi.org/10.1016/j.compedu.2019.103789

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Strelan, P., Osborn, A., & Palmer, E. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. Educational Research Review, 30, 100314. https://doi.org/10.1016/J.EDUREV.2020.100314

Soni, A., & Kumari, S (2017). The role of parental math anxiety and math attitude in their children's math achievement. International Journal of Science and Mathematics Education, 15(2), 331-347. https://doi.org/10.1007/s10763-015-9687-5

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, pages3–20. https://doi.org/10.1007/s10798-015-9304-5

Timofte Anca Elena. (2022). Bazele psihopedagogice ale învățării matematicii și formarea limbajului matematic la elevii din clasele primare. In: Probleme actuale ale științelor umanistice. Analele științifice ale doctoranzilor și competitorilor. Vol.20, Partea 1, Chişinău, pp. 176-180.

Tufeanu, M., Robu, V. (2019). Dimensions of math anxiety among primary schoolage romanian children. Journal of Innovation in Psychology, Education and Didactics, Vol. 23 (2), 215 – 233, https://www.researchgate.net/publication/350735548_DIMENSIONS_OF_MATH_ANXIETY_AMONG_PRIMARY_SCHOOL-_AGE_ROMANIAN_CHILDREN

Visu-Petra, L. (2018). Diminuarea anxietății de matematică în perioada școlară timpurie: O intervenție de tip tutoring cognitiv versus antrenamentul memoriei de lucru în dezvoltarea conceptului de număr. https://www.minimanx.com/wp-content/uploads/2018/12/raport-2018-TE-Visu-Petra.pdf

Wing, JM. (2006). Computational Thinking. Communication of the ACM, 49, pp. 33-35. https://doi.org/10.1145/1118178.1118215

Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. Educational Research Review, 30. https://doi.org/10.1016/j.edurev.2020.100326

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

TURKEY

Adesoji, F. A. & Yara, P. O. (2008). Some student factors as correlates of achievement in mathematics in Southwestern Nigeria. European Journal of Scientific Research, 19(3), 424-434.

Ağdacı, A.Y. (2021). Examination of the reasons for eight grade students' mathematics anxiety who are suffering from mathematics through student interviews (Unpublished master thesis). İstanbul Sabahattin Zaim University, İstanbul, Turkey.

Aiken L.R. (1970). Attitudes toward mathematics. Review of Educational Research, 40, 551-596.

Ak, Y. & Ertekin, E. (2020). A Study on the relationship between number sense and math anxiety of 7th and 8th grade students. OPUS, 16(31): 4047-4076.

Akkurt, Z. (2021). Examining The Relationship Between Classroom Teachers Views on Mathematics Teaching and Students Math Anxiety (Unpublished master thesis). Kahramanmaraş Sütçü İmam University, Kahramanmaraş, Turkey.

Altun, M. (2000). Matematik Öğretimi. Bursa: Alfa Aktüel Yayınları.

Altun, E. (2020). Investigation Of Distance Education Trainers' Pedagogical Competencies Through Distance Education Course Videos (Unpublished master thesis). Ondokuz Mayıs University, Samsun, Turkey.

Aminger, W., Hough, S., Roberts, S. A., Meier, V., Spina, A. D., Pajela, H. & Bianchini, J. A. (2021). Preservice secondary science teachers' implementation of an NGSS practice: Using mathematics and computational thinking. Journal of Science Teacher Education, 32(2), 188-209.

Anistyasari, Y. & Kurniawan, A. (2018). Exploring computational thinking to ımprove energyefficient programming skills. Proceedings of MATEC Web of Conferences, 197, 15011.

Arslan, A. (2008). The effects of web supported instruction and use of instructional materials on students? Mathematics anxieties, attitudes and achievements (Unpublished doctoral thesis). Marmara University, İstanbul, Turkey.

Ash, K. (2012). Educators view "flipped" model with a more critical eye. Education Week, 32(2), 6-7.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Balcı, B. (2022). Investıgatıon of Mathematıcal Skills of 8-12 Years Old Students in Robotıcs and Codıng Training Process (unpublished master thesis). Eskisehir Osmangazi University, Turkey.

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

Batdı, V. (2023). Effectiveness of the Constructivist Approach to Learning: A Mixed-Meta Method Study. Education and Science, 1-28.

Bostancı, Y. (2020). Mathematics Anxiety of Primary School 4th Grade Students Examining the Relationship Between Mathematics Achievements and Determining the Factors that Cause Math Anxiety (unpublished master thesis). Erzincan Binali Yıldırım University, Erzincan, Turkey.

Bozal, M. (2022). Effect of Math Supported Introductory Programing Education on Computational Thinking (Unpublished master thesis). Ondokuz Mayıs University, Turkey.

Brown, C. A & Baird, J. (1993). Inside the teacher: Knowledge, beliefs, and attitudes in Research ideas in the classroom High school mathematics. New York : Macmillan.

Bursa, S. (2023). The view of prospective social studies teachers on blended learning. Turkish Online Journal of Distance Education-TOJDE, 24(1), 185-199.

Butt, A. (2014). Student views on the use of a flipped classroom approach: Evidence from Australia. Business Education & Accreditation, 6(1) 33-43.

Cates, G. L. & Rhymer, K. N. (2003). Examining the relationship between mathematics anxiety and mathematics performance: An instructional hierarchy perspective. Journal of Behavioral Education, 12, 23-34. https://doi.org/10.1023/A:1022318321416.

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.

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).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Çankaya, S., Durak, G., & Yünkül, E. (2017). Education on programming with robots: Examining students' experiences and views. Turkish Online Journal of Qualitative Inquiry, 8(4), 428-445.

Çelebi, M. & Su, S. (2022). The relationship between the mathematical-oriented epistemolojik beliefs, mathematical self-sufficiency perceptions and mathematics anxiety of high school students. Journal of Social, Humanities and Administrative Sciences, 8(59):2080-2089.

Çınar, S. (2020). Educational robotics supported STEM course for prospective science teachers. Turkish Studies, 15, 7.

Çırak Kurt, S. (2017). A blended learning experience. Elementary Education Online, 16(2): 860-886.

Dağbaşı, G. (2017). İlköğretim 6. sınıf öğrencilerinin matematik dersine ilişkin duyuşsal özelliklerinin incelenmesi (unpublished master thesis). Doğu Akdeniz Üniversitesi, Kıbrıs.

Dede, Y. & Dursun, Ş. (2008). An investigation of primary school students' mathematics anxiety levels. Journal of Uludağ University Faculty of Education, 21 (2), 295 -312.

Demir, S. & Durmaz, M. (2018). A opinions of elementary maths teachers about maths anxiety and their intervention methods. Academia Journal of Educational Research, 3(1), 17-27.

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years?. Frontiers in psychology, 7, 508. https://doi.org/10.3389/fpsyg.2016.00508.

Dölek, P. (2022). The Effects Of Parents' Math Anxiety on Mathematics Achievement, Attitude and Anxiety of Primary School Students (Unpublished master thesis). Niğde Ömer Halisdemir University, Turkey.

Duman, S. N. (2020). Evaluation of the distance education process carried out during the epidemic period. Milli Eğitim Dergisi, 49(1), 95-112.

Dursun, C. (2018). Examining The Effect of Social Media Supported Blended Learning Method on Students' Mathematics Achievements and Self-Efficacy Perceptions (Unpublished master thesis). Marmara University, İstanbul, Turkey.

Ekin, H. & Şanlı-Kula, K. (2022). Analysis of secondary school students' exam and mathematics anxiety. TEBD, 20(1), 199-229. https://doi.org/10.37217/tebd.1033776

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Francis, C. A. (2017). Student rates of outside preparation before class discussion of new course topics: A case study of aflipped classroom. In Information Resourses Management Association (Ed.), Flipped instruction: Breakthroughs in research and practice (pp. 1-14). Hershey, PA: IGI Global.

Göksoy, S. & Yılmaz, İ. (2018). The opinions of information relations teacher and their students with regard to lessons of robots and decoding. Düzce University Journal of Social Sciences, 8 (1), 178-196.

Gülbahar, Y., Kert, S. B. & Kalelioğlu F. (2019). The self-efficacy perception scale for computational thinking skill: validity and reliability study. Turkish Journal of Computer and Mathematics Education, 10(1), 1-29.

Gürel, R. & Yetkin-Özdemir, İ.E. (2020). Investigation of gifted and non-gifted middle school students' mathematics anxiety levels. MAKÜ Journal of Faculty Education, 52, 261-286.

Hangün, M.E (2019). Effect of Robot Programming Education on Students' Mathematical Achievement, Maths Anxiety, Programming Self-Efficacy and Stem Attitude (Unpublished master thesis). Fırat University, Elazığ, Turkey.

Jonassen, D. H. (2000). Computers as mindtools for schools: Engaging critical thinking (2nd ed.). Upper Saddle River, NJ: Merrill.

Kaba, Y. & Şengül, S. (2018). The relationship between middle school students' mathematics anxiety and their mathematical understanding. Pegem Journal of Education and Instruction, 8(3): 599-621.

Karaca, C. & Ocak, M. A. (2017). Effects of flipped learning on university students' academic achievement in algorithm sand programming education. International Online Journal of Educational Sciences, 9(2), 527-543.

Kartal, B., Baltacı, S., & Yıldız, A. (2022). Adapting the mathematics self-efficacy and anxiety questionnaire into turkish and examining its relationship with mathematical self-concept. Journal of Kırşehir Education Faculty, 23(3), 2471-2522.

Kasalak, İ. (2017). Effects of robotic coding activities on the effectiveness of secondary school students' self-efficacy and student experience about activities (Unpublished master thesis). Hacettepe University, Ankaa, Turkey.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Kazez, H. & Genç, Z. (2016). A new approach in teaching of mathematics in primary school: Lego MoretoMath. Journal of Instructional Technologies & Teacher Education, 5(2), 59-71.

Kiamanesh, A. R. (2004). Factors affecting Iranian students' achievement in mathematics. Paper presented in the First IEA International Research Conference, Cyprus.

Koç, E. S. (2021). What kind of distance education? An evaluation of the studies done at the end of 1 year. International Anatolia Academic Online Journal Social Sciences Journal, 7(2), 13-26.

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.

Leonard, J., Buss, A., Gamboa, R., Mitchell, M., Fashola, O. S., Hubert, T., & Almughyirah, S. (2016). Using robotics and game design to enhance children's self-efficacy, STEM attitudes, and computational thinking skills. Journal of Science Education and Technology, 25(6), 860-876.

Lockwood, J. & Mooney, A. (2017). Computational thinking in education: Where does it fit? A systematic literary review. Retrieved from: https://arxiv.org/abs/1703.07659

Mason, G. S., Shuman, T. R. & Cook, K. E. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. IEEE. Transactions on Education, 56(4), 430-435.

Mataric, M. J., Koenig, N. P., & Feil-Seifer, D. (2007). Materials for Enabling Hands-On Robotics and STEM Education. In AAAI spring symposium: Semantic scientific knowledge integration (pp. 99-102).

Mert, M. & Baş, F. (2019). The anxiety and metacognitive awareness levels of secondary school students towards mathematics and the effect of related variables on their mathematics achievements. Turkish Journal of Computer and Mathematics Education, 10(3): 732-756.

Milli Eğitim Bakanlığı (2018). Matematik Dersi Öğretim Programı, Ankara

Milli Eğitim Bakanlığı (2018). Bilişim Teknolojileri ve Yazılım Dersi Öğretim Programı, Ankara

Monroy-Hernández, A., & Resnick, M. (2008). Feature empowering kids to create and share programmable media. Interactions, 15(2), 50-53.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Müller, C., & Mildenberger, T. (2021). Facilitating flexible learning by replacing classroom time with an online learning environment: A systematic review of blended learning in higher education. Educational Research Review, 34, 100394. https://doi.org/10.1016/j.edurev.2021.100394

Nugent, G., Barker, B., Grandgenett, N., & Adamchuk, V. I. (2010). Impact of robotics and geospatial technology interventions on youth STEM learning and attitudes. Journal of Research on Technology in Education, 42(4), 391-408.

Papanastasiou, C. (2000). Internal and external factors affecting achievement in mathematics: Some findings from TIMSS. Studies in Educational Evaluation, 26, 1-7.

Petre, M., & Price, B. (2004). Using Robotics to Motivate 'Back Door' Learning. Education and Information Technologies, 9(2), 147–158. https://doi.org/10.1023/B:EAIT.0000027927.78380.60

Proctor, C. & Blikstein, P. (2018). How broad is computational thinking? A longitudinal study of practices shaping learning in computer science. Proceedings of the 13th International Conference of the Learning Sciences, 1, 544-551.

Rovai, A.P. & Jordan, H.M. (2004). Blended Learning and sense of community: A comparative analysis with traditional and fully online graduate courses. The International Review of Research in Open and Distance Learning, 5(2).

Rowe, E., Asbell-Clarke, J., Cunningham, K. & Gasca, S. (2017). Assessing implicit computational thinking in Zoombinis Gameplay: Pizza Pass, Fleens & Bubblewonder Abyss. Proceedings of the Annual Symposium on Computer-Human Interaction in Play, 195-200.

Ruffell, M., Mason, J. & Barbara, A. (1998). Studying attitude to mathematics. Educational Studies in Mathematics, 35, 1-18.

Sari, I. F., Rahayu, A., Apriliandari, D. I., & Sulisworo, D. (2018). Blended learning: Improving students' motivation in English teaching learning process. International Journal of Languages' Education and Teaching, 6(1), 163-170.

Savaş, E., Taş, S. & Duru, A. (2010). Factors Affecting Students' Achievement in Mathematics. İnönü University Journal of The Faculty Of Education, 11(1), 113-132.

Silk, E. M., Higashi, R., Shoop, R., & Schunn, C. D. (2010). Designing technology activities that teach mathematics. The Technology Teacher, 69(4), 21-27.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Sloan, T., Daane, C.J., & Giesen, J. (2002). Mathematics anxiety and learning styles: What is the relationship in elementary preservice teachers?. School Science & Mathematics, 102(2), 84-87.

Somyürek, S. (2015). An effective educational tool: construction kits for fun and meaningful learning. International Journal of Technology and Design Education, 25(1), 25-41.

Speller, S. (2015). Mathematic steacher's experience with flipped learning: A phenomeno graphic approach (Theses Dissertations). The University of Toledo.

Strawhacker, A., & Bers, M. U. (2015). "I want my robot to look for food": Comparing Kindergartner's programming comprehension using tangible, graphic, and hybrid user interfaces. International Journal of Technology and Design Education, 25(3), 293-319.

Stripling, T., & Simmons, B. (2016). Get Students Revved Up! Robotics Brings Excitement to STEM. Tech Directions, 75(7), 13.

Sung, W., Ahn, J., & Black, J. B. (2017). Introducing computational thinking to young learners: Practicing computational perspectives through embodiment in mathematics education. Technology, Knowledge and Learning, 22(3), 443-463.

Tabak, S. (2019) Research Tendencies in Turkey on the "Realistic Mathematics Education": A Research of Thematic Content Analysis. Journal of Kırşehir Education Faculty, 20(2), 481-526.

Tabakçı, S. (2018). An investigation of the relationship between mathematics anxiety and learned helplessness of children (Unpublished master thesis). Toros University, Mersin, Turkey.

Tekin, Y., & Keser, H. (2020). The effect of using robotic activities in mathematics teaching on achievement. Mediterranean Journal of Educational Research, 14(34), 472-493.

Thomson, S., Lokan, J., Lamb S., & Ainley, J. (2003). Lessons from the third international mathematics and science study. TIMSS Australia Monograph Series. Australian Council for Educational Research.

Thorne, K. (2003). Blended learning: How to integrate on-line and traditional learning, London. Kogan Page.

Tobias, S. & Duffy, T. M. (2009). Constructivist Instruction: Success Or Failure?. New York, NY: Routledge.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Utami, I. S., 2018. The effectiveness of blended learning as an instructional model in vocational high school. Journal of Educational Science and Technology (EST), 4(1), 74-83.

Üstün, A. B., & Çil, B. D. (2022). Examining the Diji Demi System in the Flipped Classrooms. Bartın University Journal of Educational Research, 6(1), 41-53.

Üstün, A. B., Zhang, K., Karaoğlan-Yilmaz, F. G., & Yilmaz, R. (2022). Learning analytics based feedback and recommendations in flipped classrooms: an experimental study in higher education. Journal of Research on Technology in Education, 1-17.

Vinson, B.M. (2001). A comparison of preservice teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. Early Childhood Education Journal, 29(2), 89-94. https://doi.org/10.1023/A:1012568711257.

Wang, D. B. (2004). Family background factors and mathematics success: A comparison of Chinese and US students. International Journal of Educational Research, 41, 40–54.

Wilkerson, M. & Fenwick, M. (2016). The practice of using mathematics and computational thinking. In C. V. Schwarz, C. Passmore, & B. J. Reiser (Eds.), Helping Students Make Sense of the World Using Next Generation Science and Engineering Practices. Arlington, VA: National Science Teachers' Association Press.

Williams, N. A., Bland, W. & Christie, G. (2008). Improving student achievement and satisfaction by adopting a blended learning approach to inorganic chemistry. Chemistry Education Research and Practice, 9(1), 43- 50.

Wing, J. M. (2006). Computational thinking. Communications of the ACM, 49(3), 33-35.

Yağcı, M. (2019). A valid and reliable tool for examining computational thinking skills. Education and Information Technologies, 24(1), 929-951.

Yalçın, N. & Akbbulut, E. (2021). Stem education and investigation of robotic coding training in stem perspective: Kızılcahamam coding example. The Journal of Turkish Social Research, 25(2), 469-490.

Yarış, H.A. (2022). Determining The Problems In Reaching The Learning Outcomes Related To Reading Comprehension Skills In The Primary School Mathematics Curriculum (unpublished master thesis). Kütahya Dumlupınar University, Turkey.

Yıldırım, K. (2020). Lessons from an exceptional distance education experience. CRES Journal, 1(1), 7-15. doi:http:// dx.doi.org/10.22596/ cresjournal.0101.7.16

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Yolcu, V. (2018). The effect of using robotics on academic success, computational thinking skills and transfer of learning in programming education (Unpublished master thesis). Süleyman Demirel University, Isparta, Turkey.

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.

Yuen T. T., Boecking M., Stone J., Tiger, E.P., Gomez, A., Guillen, A. et al. (2014). Group tasks, activities, dynamics, and interactions in collaborative robotics projects with elementary and middle school children. Journal of STEM Education, 15(1): 39-45.

Zembylas, M., Theodorou, M. & Pavlakis, A. (2008). The role of emotions in the experience of online learning: challenges and opportunities. Educational Media International, 45(2), 107–117.

Van den Heuvel-Panhuizen, M. (2001). Realistic mathematics education as a work in progress. In F. L. Lin (Ed.), Common Sense in Mathematics Education, Proceedings of 2001 The Netherlands and Taiwan Conference on Mathematics Education (pp. 1-43). Taipei, Taiwan.

INTERNET RECOURCES

https://www.derslink.com

https://www.globsyn.edu.in/blog/how-is-flipped-classroom-flipping-the-role-of-traditional-classroom-pedagogy

https://meb.gov.tr

https://www.mjmobbs.com/p/fcle.html

https://www.morpakampus.com

https://mufredat.meb.gov.tr/Dosyalar/201813017165445

https://www.okulistik.com

https://tez.yok.gov.tr/UlusalTezMerkezi

https://www.vitaminegitim.com

LATVIA

American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (DSM– 5). Washington, DC: American Psychiatric Publishing

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Amo, D., Fox, P., Fonseca, D., Poyatos, C. (2021). Systematic review on which analytics and learning methodologies are applied in primary and secondary education in the learning of robotics sensors. Sensors, 21(1), 153.

Angel-Fernandez, J. M., Vincze, M. (2018). Towards a definition of educational robotics. In Austrian Robotics Workshop 2018.Vol. 37.

Angeli, C., Giannakos, M. (2020). Computational thinking education: Issues and challenges. Computers in Human Behavior, 105, 106185.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. Current Directions in Psychological Science, 11(5), 181–185.

Avotiņa, M., Buliņa, E., Pogule, G.B., Zīlīte, A. (2022). The impact on the mathematics curriculum for grade 7–9 in the competency-based approach in the learning process in Latvia. In Proceedings of Scientific Papers Human, Technologies and Quality of Education.

Baloglu, M., Kocak, R. (2006). A multivariate investigation of the differences in mathematics anxiety. Personality. Individiduality. Diference. 40, 1325–1335.

Bhagat, K. K., Chang, C. N., Chang, C. Y. (2016). The Impact of the Flipped Classroom on Mathematics Concept Learning in High School. Educational Technology & Society, 19 (3), 134–142.

Biechele, M, Kranz, D., Macdonald, J., Rautenstrauch, C., Reinmann, G., Rösler, D., Schulmeister, R., Würffel, N., Fremdsprache, Deutsch, Heft, 42/2010 Blended Learning. Max Hueber.

Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A systematic review. Computers & Education, 58(3), 978-988.

Bergmann, J., Sams, A. (2012). Flip Your Classroom: Reach Every Student in Every Class Every Day. International Society for Technology in Education

Bergmann, J. (2013). Key Questions You Should Ask Before You Flip Your Class. http://flglobal.org/key-questions-you-should-ask-before-you-flipyour-class/

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.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Boettcher, J. V., Conrad, R. M. (2016). The Online Teaching Survival Guide. Second edition. San Francisco, CA: Jossey-Bass

Brennan, K., Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. In Proceedings of the 2012 annual meeting of the American educational research association, Vancouver, Canada, Vol. 1, 25.

Bunce, D., Handley, R., Gaines, S. O. (2008). Deppression, anxiety, and within-person variability in adults aged 18 to 85 years. American Psychological Association, 23(4), 848-858.

Catlin, D., Kandlhofer, M., Cabibihan, J., Angel-Fernandez, J., Holmquist, S., Csizmadia, A. (2019). EduRobot Taxonomy. In Smart Learning with Educational Robotics. Cham: Springer International Publishing

Cipora, K., Szczygiel, M., Willmes, K., Nuerk, H. C. (2015). Math anxiety assessment with the abbreviated math anxiety scale: applicability and usefulness: insights from the polish adaptation. Frontiers in Psychology. 6, 1833.

Chaldi, D., Mantzanidou, G. (2021). Educational robotics and STEAM in early childhood education. Advances in Mobile Learn Educational Research, 1(2): 72-81

Chew, E., Jones, N., Turner, D. (2008) Critical Review of the Blended Learning Models Based on Maslow's and Vygotsky's Educational Theory' in Hybrid Learning and Education. Berlin, Springer Verlag Publ.

Chen, G., Shen, J., Barth-Cohen, L., Jiang, S., Huang, X., Eltoukhy, M. (2017). Assessing elementary students' computational thinking in everyday reasoning and robotics programming. Computers & Education, 109, 162–175.

Ching, Y. H., Hsu, Y. C., Baldwin, S. (2018). Developing computational thinking with educational technologies for young learners. TechTrends, 62 (6), 563-573.

Chiesi, F., Primi, C. (2010). Cognitive and non-cognitive factors related to students' statistics achievement. Statistics. Education. Research. Journal. 9, 6–26.

Creative Classroom Lab. (2015). Innovative Teaching and Learning with Tablets. Brussels: European Schoolnet

Croyle, K. L., Weimer, A. A., Eisenman, R. (2012). Context of assessment changes relationships between test anxiety and related variables. International Journal of Adolescence and Youth, 17, 11– 20.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Cruise, R., Cash, R., Bolton, D. (1985). Development and validation of an instrument to measure statistical anxiety in Proceedings of the American Statistical Association, Section on Statistical Education, Las Vegas, NV.

Csizmadia, A., Curzon, P., Dorling, M., Humphreys, S., Ng, T., Selby, C., Woollard, J. (2015). Computational thinking-A guide for teachers. 79th International Scientific Conference of the University of Latvia.

Dorenkamp, M. A., Vik, P. (2018). Neuropsychological assessment anxiety: A systematic review. Educational Publishing Foundation, 3(3), 192-211

Daniela, L. (2018). Human, Technologies and Quality of Education = Cilvēks, tehnoloģijas un izglītības kvalitāte: konferences rakstu krājums. The international conference of the University of Latvia.

Daniela, L. (2022). Tehnoloģijas izglītībā. Nacionālā enciklopēdija. https://enciklopedija.lv/skirklis/58012-tehnolo%C4%A3ijasizgl%C4%ABt%C4%ABb%C4%81 (in Latvian).

Dardedze. (2016). Aptaujas "Bērnu audzināšana" http://www.centrsdardedze.lv/lv/uzzinai/petijumi (in Latvian).

Education System in Latvia (2020). Ministry of education and Science of Repuvlic of Latvia https://www.izm.gov.lv/en/education-system-latvia

Eguchi, A. (2010). What is Educational Robotics? Theories behind it and practical implementation.

EU, (2020) Blended learning in school education – guidelines for the start of the academic year 2020/21

Evripidou, S., Georgiou, K., Doitsidis, L., Amanatiadis, A. A., Zinonos, Z., Chatzichristofis, S. A. (2020). Educational robotics: Platforms, competitions and expected learning outcomes. IEEE access, 8.

Field, A. P. (2014). Skills in Mathematics and Statistics in Psychology and Tackling Transition. York: The Higher Education Academy.

Felicia, A., Sharif, S. (2014). A Review on Educational Robotics as Assistive Tools For Learning Mathematics and Science, International Journal of Computer Science Trends and Technology, 2(2).

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Fonteyne, L., De Fruyt, F., Dewulf, N., Duyck, W., Erauw, K., Goeminne, K., et al. (2015). Basic mathematics test predicts statistics achievement and overall first year academic success. European Journal Psychological Education 30, 95–118.

Garrison, D.R., Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. Internet and Higher Education

General education (2020). Natioanl Centre for education of republic of Latvia https://www.visc.gov.lv/en/general-education

Gomoll, A., Hmelo-Silver, C. E., Sabanović, S., Francisco, M. (2016). Dragons, ladybugs, and softballs: Girls' STEM engagement with human-centered robotics. Journal of Science Education and Technology, 25(6).

Graham, C.R. (2006) Blended Learning Systems: Definition, Current Trends, and Future Directions. The Handbook of Blended Learning: Global Perspectives, Local Designs. San Francisco, Pfeiffer Publ.

Hao, Y., Lee, K. (2016). Teaching in Flipped Classrooms: Exploring Pre-service Teachers' concerns. Computers in Human Behaviour, 57, 250 – 260.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. Journal for Research in Mathematics Education, 21, 33–46.

Hopko, D. R., Mahadevan, R., Bare, R. L., Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS): construction, validity, and reliability. Assessment 10, 178–182.

Hsu, Y. C., Irie, N. R., Ching, Y. H. (2019). Computational thinking educational policy initiatives (CTEPI) across the globe. TechTrends, 63(3), 260-270.

Hwang, W. Y., Wu, S. Y. (2014). A case study of collaboration with multi-robots and its effect on children's interaction. Interactive Learning Environments, 22(4).

Kazelskis, R. (1998). Some dimensions of mathematics anxiety: a factor analysis across instruments. Education Psychology Measurement 58, 623–633.

Keith, P. K., Sullivan, F. R., Pham, D. (2019). Roles collaboration and the development of computational thinking in a robotics learning environment. In Computational thinking education. Springer.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Keren, G., Fridin, M. (2014). Kindergarten Social Assistive Robot for children's geometric thinking and metacognitive development in preschool education: A pilot study. Computers in Human Behavior, 35.

Kite, V., Park, S., Wiebe, E. (2021). The code-centric nature of computational thinking education: A review of trends and issues in computational thinking education research. Sage Open, 11(2).

Konijn, E. A., Hoorn, J. F. (2020). Robot tutor and pupils' educational ability: Teaching the times tables. Computers & Education, 157, 103970.

Krasnova, T. A. (2015) Paradigm Shift: Blended Learning Integration in Russian Higher Education. Procedia – Social and Behavioral Sciences

Labusch, A., Eickelmann, B., Vennemann, M. (2019). Computational thinking processes and their congruence with problem-solving and information processing. In Computational thinking education 65-78. Springer, Singapore.

Lai, C., Hwang, G. (2016). A Self-regulated Flipped Classroom Approach to Improving Students' Learning Performance in a Mathematics Course. Computers & Education, 100, 126 – 140.

Leoste, J., Heidmets, M. (2019). The impact of educational robots as learning tools on mathematics learning outcomes in basic education. Digital Turn in Schools— Research, Policy, Practice, pp. 203-217.

Leonard, J., Buss, A., Gamboa, R., Mitchell, M., Fashola, O. S., Hubert, T., Almughyirah, S. (2016). Using robotics and game design to enhance children's self-efficacy, STEM attitudes, and computational thinking skills. Journal of Science Education and Technology, 25(6), 860–876.

LETERA. Latvijas Elektrotehnikas un elektronikas rūpniecības asociācija. (2019). Robotikas izglītības iestādes un pulciņi.

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. Journal for Research in Mathematics Education, 30, 520–540.

Macher, D., Paechter, M., Papousek, I., Ruggeri, K., Freudenthaler, H., Arendasy, M. (2013). Statistics anxiety, state anxiety during an examination, and academic achievement. Journal of Educational Psychology. 83, 535–549.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Mannila, L., Settle, A., Dagiene, V. (2014). Computational Thinking in K-9 Education.

Matemātika 1.–9. klasei. Mācību priekšmeta programmas paraugs [Mathematics 1-9 grade. Mathematics curricula]. (2015). Valsts izglītības satura centrs, Skola2030 (in Latvian)

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)

Master, A., Cheryan, S., Moscatelli, A., Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. Journal of Experimental Child Psychology, 160.

Marín-Marín, J. A., Moreno-Guerrero, A. J., Dúo-Terrón, P., LópezBelmonte, J. (2021). STEAM in education: a bibliometric analysis of performance and cowords in Web of Science. International Journal of STEM Education, 8(1), 1-21.

MK, Ministru kabineta noteikuma projekta "Attālināto mācību organizēšanas un īstenošanas kārtība" sākotnējās ietekmes novērtējuma ziņojums (anotācija). Pieejams: http://webcache.googleusercontent.com/search?q=cache:NNdnmcuybewJ:tap.mk.gov.lv/doc/2021_03/IZMAnot_020321_attalinatas.170.docx+&cd=13&hl=lv&ct=clnk&gl=lv

Menekse, M., Higashi, R., Schunn, C. D., Baehr, E. (2017). The role of robotics teams' collaboration quality on team performance in a robotics tournament. Journal of Engineering Education, 106(4), 564– 584.

Mok, H. N. (2014). Teaching Tip: The Flipped Classroom. Journal of Information Systems Education, 25 (1), 7-11.

OECD (2022), Education at a Glance 2022: OECD Indicators, OECD Publishing, Paris.

Onwuegbuzie, A., Wilson, V. (2003). Statistics anxiety: nature, etiology, antecedents, effects, and treatments–a comprehensive review of the literature. Teaching in Higher Education, 8, 195–209.

Organisation for Economic Co-operation and Development (2016). PISA 2015 Results in Focus. https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf

Paechter, M., Luttenberger, S., Macher, D., Berding, F., Papousek, I., Weiss, E. M., et al. (2015). The effects of nine-week summer vacation: losses in mathematics and gains in reading. Eurasia Journal of Mathematics, Science and Technology Education. 11, 1339–1413.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Papert, S. (1996). An exploration in the space of mathematics educations. International Journal of Computers for Mathematical Learning, 1(1), 95-123.

Papert, S. (1980). Children, computers, and powerful ideas. Harvester Press, Unitend Kingdom. DOI, 10, 978-3.

Potvin, O., Bergua, V., Meillon, C., Le Goff, M., Bouisson, J., Dartigues, J.F., Amieva, H. (2013). State anxiety and cognitive functioning in older adults. The American Journal of Geriatric Psychiatry, 21, 915–924.

Qu, J. R., Fok, P. K. (2021). Cultivating students' computational thinking through student–robot interactions in robotics education. International Journal of Technology and Design Education, 1-20.

RTA, LU, RSU, EDI (2020). Projekta papildu rezultāti Nr. 35, 36, 37 un 38. https://lzp.gov.lv/wp-content/uploads/2021/02/35_lidz_38_zinojumi.pdf

Selby, C., Woollard, J. (2013). Computational thinking: the developing definition. http://eprints.soton.ac.uk/id/eprint/356481

Shih, B. Y., Chang, C. J., Chen, Y. H., Chen, C. Y., Liang, Y. D. (2012). LEGO NXT information on test dimensionality using Kolb's innovative learning cycle. Natural Hazards, 64(2).

Sun, M. K., Alkon, D. L. (2014). Stress: Perspectives on its impact on cognition and pharmacological treatment. Behavioural Pharmacology, 25, 410–424.

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

Staker, H., Horn, M. B. Classifying K-12 Blended Learning. https://www.christenseninstitute.org/wp-content/uploads/2013/04/Classifying-K-12-blended-learning.pdf

Toivola, M., Silfverberg, H. (2014). Flipped Learning –Approach in Mathematics Teaching – A Theoretical Point of View. Annual Symposium of the Finnish Mathematics and Science Education Research Association. http://www.academia.edu/17424961/FLIPPED_LEARNING_APPROACH_IN_MATHEMATICS_TEACHING_A_THEORETICAL_POINT_OF_VIEW

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Testa, A., Giannuzzi, R., Sollazzo, F., Petrongolo, L., Bernardini, L., Daini, S. (2013). Psychiatric emergencies (part I): psychiatric disorders causing organic symptoms, European Review for Medical and Pharmacological Sciences, 17(1), 55-64.

Tuckman, B. W. (1998). Using tests as an incentive to motivate procrastinators to study. Journal of Experimental Education. 66, 141–147.

Tucker, C. R., Wyco, T., Green, J. T. (2017). Blended Learning in Action.

Veinberga, G. (2022). Izglītojošās robotikas metodisko materiālu izstrāde un aprobācija pilnveidotā mācību satura un pieejas ieviešanai pamatskolā. Maģistra darbs, LU PPMF (in Latvian).

VISC, (2021). Vadlīnijas klātienes, kombinētu un attālinātu mācību īstenošanai Metodiski ieteikumi vispārējās un profesionālās izglītības iestādēm COVID-19 izplatības laikā 2021. gada 8. Janvārī https://skola2030.lv/admin/filemanager/files/2/Vadlinijas%20attalinatam%20macibam_31032021.pdf

Vitanza, A., Rossetti, P., Mondada, F., Trianni, V. (2019). Robot swarms as an educational tool: The Thymio's way. International Journal of Advanced Robotic Systems, 16(1).

Wing, J. M. (2019). A conversation about computational thinking. Chapter, 8, 127-140. https://policies.education.nsw.gov.au/content/dam/main-education/teaching-andlearning/education-for-a-changing-world/media/documents/ComputationalConversation_1_A.pdf

Yongheng, Z., Feng, Z., Hongxia, L. (2020). Developing Computational thinking education though training among Chinese students. Revista de Psicología del Deporte, Journal of Sport Psychology, 29(4), 194-209.

You, H.S., Chacko, S.M. (2021). Examining the Effectiveness of a Professional Development Program: Integration of Educational Robotics into Science and Mathematics Curricula. Journal of Science Education and Technology. 30, 567–581.

Zhong, B., Wang, Y. (2021). Effects of roles assignment and learning styles on pair learning in robotics education. International Journal of Technology and Design Education, 31(1), 41-59.

Zhong, B., Xia, L. (2021). Effects of new coopetition designs on learning performance in robotics education. Journal of Computer Assisted Learning, 20(2) 18-20.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Zviel-Girshin, R., Luria, A., Shaham, C. (2020). Robotics as a tool to enhance technological thinking in early childhood. Journal of Science Education and Technology, 29(2), 294-302.

POLAND

Bunda, M. (2009). Matematyka w szkołach po nowemu. Polityka.

Code.org. (2023). Pobrano z lokalizacji Code.org: https://code.org/

Edukacja STEAM (science, technology, engineering, art, maths). (2023). Pobrano z lokalizacji https://www.mentorpolska.pl/: https://www.mentorpolska.pl/steam

Ehmke, R. (2022). How to Help Kids With Math Anxiety. Pobrano z lokalizacji https://childmind.org/: https://childmind.org/article/help-kids-with-math-anxiety/

Flipped Classroom. (2022). Pobrano z lokalizacji International Faculty of Engineering: https://www.ife.p.lodz.pl/en/flipped-classroom

Fuchs, L. S. (2016). The role of cognitive processes, foundational math skill, and calculation accuracy and fluency in word-problem solving versus prealgebraic knowledge. Developmental psychology, strony 2085–2098.

Guide to Blended Learning. CHAPTER 1 : Blended Learning. (2017). Pobrano z lokalizacji Commonweth of Learning: https://openbooks.col.org/blendedlearning/chapter/chapter-1-blended-learning/

Helen Moriah Sokolowski, D. A. (2017, October 17). Who Is Afraid of Math? What Is Math Anxiety? And What Can You Do about It? Pobrano z lokalizacji https://kids.frontiersin.org: https://kids.frontiersin.org/articles/10.3389/frym.2017.00057

K. Bobko, M. B. (2018). Programowanie i robotyka w edukacji wczesnoszkolnej. Kraków: Małopolskie Centrum Doskonalenia Nauczycieli.

Liga robotów. (2023). Pobrano z lokalizacji gov.pl: https://www.gov.pl/web/edukacja-i-nauka/szef-mein-przekazujemy-10-mln-zl-aby-zainteresowac-uczniow-tematyka-robotyki

Lopez-Caudana, E. R.-M.-P.-A. (2020). Using Robotics to Enhance Active Learning in Mathematics: A Multi-Scenario Study. Mathematics, str. 2163.

Mańka, A. (2017). Zdolności algorytmicznego rozwiązywania problemów w klasach I–III – koncepcja i narzędzia. Sosnowiec: Oficyna Wydawnicza Humanitas.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Math anxiety: What it is and how to overcome it. (2022, September 28). Pobrano z lokalizacji Medical News Today: https://www.medicalnewstoday.com/articles/math-anxiety-definition-symptoms-causes-and-tips

Matzoo. (2010-2023). Pobrano z lokalizacji Matzoo: https://www.matzoo.pl/

Monika Wiśniowska, K. Z. (2023). Gamifikacja czyli inna odsłona edukacji. Pobrano z lokalizacji Edukacja - inspiracje: https://paderewski.lublin.pl/edukacja-i-inspiracje/pl/gamifikacja-czyli-inna-odslona-edukacji

Olena Kuzminska, N. M.-T. (2017). Flipped Learning Model: Tools and Experience of Its Implementation in Higher Education. The New Educational Review, strony 189-200.

Peer, Z. &. (2018). Flipped classroom: A new innovation in teaching and learning. International Journal of Movement Education and Social Science, strony 275-280.

Planeta robotów. (2023). Pobrano z lokalizacji Planeta robotów: https://www.planetarobotow.pl/polkolonie?gclid=CjwKCAjwq-WgBhBMEiwAzKSH6Mz-l8aM5K4Iwig3jBcaWqoHMPG6Gyv5HXzbUIupExIsjCWT35aBdxoCTMoQAvD_BwE

Podstawa programowa - matematyka. Klasy IV-VIII. (2017). Pobrano z lokalizacji Podstawa progrwamowa - szkoła podstawowa: https://podstawaprogramowa.pl/Szkola-podstawowa-IV-VIII/Matematyka

Podstawa Programowa - szkoła podstawowa I-III. (2017, luty 14). Pobrano z lokalizacji Podstawa Programowa: https://podstawaprogramowa.pl/Szkola-podstawowa-I-III

(2017). Podstawa programowa kształcenia ogólnego z komentarzem. Szkoła podstawowa. Matemetyka. Warszawa: Ośrodek Rozwoju Edukacji.

Robomaticon. (2019). Pobrano z lokalizacji Robomaticon: https://robomaticon.pl/pl

Robotic Arena. (2023). Pobrano z lokalizacji Robotic Arena: https://roboticarena.pl

Robotyka. (2023). Pobrano z lokalizacji Uniwersytet Rozwoju: https://uniwersytetrozwoju.pl/oferta/warsztaty/robotyka/

S., C.-F. (2021). Learning to teach mathematics with robots: Developing the 'T' in technological pedagogical content knowledge q. Research in Learning Technology.

Scratch. (2022). Pobrano z lokalizacji Scratch: https://scratch.mit.edu/

Sevillano-Monje, V. M.-G.-G. (2022). The Flipped Classroom and the Development of Competences: A Teaching Innovation Experience in Higher Education. Education Sciences.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Supekar, K. I. (2015). Remediation of Childhood Math Anxiety and Associated Neural Circuits through Cognitive Tutoring. The Journal of neuroscience, strony 12574–12583.

Zasoński, S. (2017). Robotyka w nauczaniu wczesnoszkolnym, czy to w ogóle możliwe? Edunews.pl.

Żeromska, A. K. (2013). Metodologia matemetyki jako przedmiot badań antropomatematycznych. Kraków: Wydawnictwo Naukowe Uniwersytetu Pedagogicznego.

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

Co-funded by
the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them. Project no. 2022-1-PL01-KA220-HED-000086524

ÇANAKKALE ONSEKİZ MART ÜNİVERSİTESİ 1992

SPOŁECZNA AKADEMIA NAUK
UNIVERSITY OF SOCIAL SCIENCES

UNIVERSITATEA LUCIAN BLAGA DIN SIBIU

LATVIJAS UNIVERSITĀTE
PEDAGOĢIJAS, PSIHOLOĢIJAS UN MĀKSLAS FAKULTĀTE

Scuola di Robotica

www.rbtsinmath.eu