

# Teaching of computer programming in Bulgarian primary school – challenges and solutions

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**Abstract** - In this paper the new school subject in Bulgarian primary school - “Computer modelling” is presented. The subject is introduced to all Bulgarian schools in 2018/2019 year as a core course in third grade (9-year-old students). The curricula for 3rd and 4th grade are outlined and some challenges and problems in implementation of the new school subject are discussed. Also several examples for solutions of main challenges are presented..

**Keywords** – computer programming, computational thinking, primary school, teaching methods

## I. INTRODUCTION

The world around us becomes more and more digitalized. Nowadays the society needs people that not only use digital devices, but also people with computational thinking who will develop high-tech environment. In [1] authors point out that “To be prepared for the jobs of the 21<sup>st</sup> century, students must not only be digitally literate but also understand key concepts of informatics.” To answer the new requirements of digital society and future jobs a lot of countries started to develop and implement new curricula in their schools with focus on informatics concepts, computational thinking, and algorithmic thinking. A lot of countries started rethinking strategies for informatics education. The school subject Informatics or Computer Science (or similar) has been introduced in different school level in different countries.

Informatics education in Bulgaria started in end of 60<sup>s</sup> years of 20<sup>th</sup> century as elective courses in Mathematical gymnasiums. As a compulsory subject it has been involved into school curricula from 1986/1987 year. During the years there were tides according place of informatics education in the school curricula. At 2016 year started new school curricula and new school subject “Computer modeling” was involved for primary school students at 3rd and 4th grade (9-10 years old). The education in the new subject started from 2018/2019 school year.

The new subject in Bulgarian primary school, problems with its implementation and possible solutions are in the focus of this paper.

## II. RELATED STUDIES

In several countries informatics concepts and programming are introduced in primary schools as compulsory courses in the curricula. In England the computing curricula for primary school is involved at

2014. [2]

Slovakia has a huge experience in informatics education at school – primary and secondary level. [3] As a mandatory course informatics is involved in Slovakian schools at 2008 year “from year 2 (7 to 8 year olds) to mid-upper secondary stage (16 to 17 year olds)”. In 2011 Slovak National Curriculum (2011) outlines two core school subjects – Elementary Informatics for grades 2 to 4 (pupils aged 7 to 10) and Informatics, for school years 5 to 11 (pupils aged 10 to 17). Since 2015 both subject are called Informatics. The subject covers domain from ICT and programming.

In other countries computer science is presented into primary school curricula as an optional course: Slovenia [4] – “Slovenian schools offer an optional elective course Computer Science to the students in the second three-year cycle of primary schools since school year 2014/2015. “

Very popular among children and parents are computing clubs provided by different organizations and companies. Also international online initiatives stimulate children, parents and teachers to self-explore concepts and ideas of informatics and programming.

Independent if computing, or computer science or informatics, are part of informal or formal education, several common problems arise:

- lack of well-prepared teachers to teach the subject in primary school or to integrate elements of programming and computing in other subjects;
- needs of adequate pedagogical approaches related to psychological and cognitive characteristics of children in primary school;
- introducing of abstract informatics concepts in understandable and accessible manner for children;
- choose of appropriate programming environment.

Regarding the pedagogical approaches, it should be mentioned that constructionism based methods create good conditions for implementation of computer programming in primary school. Some example of good practices could be found in [4], [5], [6]. In the frame of ScratchMath project [5] outline “5E” framework of activities: Explore, Explain, Envisage, Exchange, bridgeE.

Authors of [7] proposed unplugged game based method for introducing computer memory, basic arithmetic operations and the idea of variables.

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### III. CURRICULA “COMPUTER MODELING” IN BULGARIAN PRIMARY SCHOOLS

#### A. Structure of the school educational system in Bulgaria

In Bulgarian educational system three school subjects related to computer science are part of the school curricula: Information technology, Informatics, and Computer modeling. Courses in Information technology are focused on computer system, application software – graphical editors, word-processing, spreadsheets, presentations, internet services, safety in internet, computer viruses etc. Courses in informatics are directed to algorithms, numbers systems, Boolean algebra, programming. Subject Computer modeling is directed to primary school and joins topics from domain of ICT and Informatics.

In primary school (1<sup>st</sup>-4<sup>th</sup> grade) students can study computing in three basic forms:

- 3<sup>rd</sup> (9 years old students) – 4<sup>th</sup> (10 years old students) grade - Compulsory subject “Computer modeling” – 1 hour per week;
- 1<sup>st</sup> – 4<sup>th</sup> grade - elective or optional – Information technology, 1 or 2 hours per week;
- Extracurricular courses in IT and Informatics – 1 or 2 hours per week, funded by National programs of Ministry of Education.

The compulsory subject “Computer modeling” has been involved since 2018/2019.

Educational process in compulsory subjects is regulated by several state documents:

- State standards – outlines competences in form of learning outcomes (LO) for every educational level.
- Syllabus for every grade - developed by the Ministry of Education; unified form for description; outlines the learning outcomes; compulsory topics; requirements for distribution of hours for different type of lessons and assessment; suggestions for activities that help to achieve LO and development of 9 competences;
- Topic schedules for the academic year, developed by teachers.

For elective or optional courses teachers develop own syllabus, that have to be approved by regional educational inspectorate.

The textbooks are free of charge for students from 1<sup>st</sup> till 7<sup>th</sup> grade. Also e-textbooks with extended interactive exercises are provided by the publishers of printed textbooks. The teachers are supported by teacher’s book with didactical suggestions for learning scenarios development and lesson implementation.

#### B. Main topics and learning outcomes in curricula “Computer modeling”

Main topics for 3<sup>rd</sup> grade are outlined in state syllabus [8] and include core knowledge domains: Digital Devices, Digital Identity, Information, and Algorithms.

The accent is on the obtaining knowledge and skills for: working with files; creating animated projects with use of algorithms with loops in visual environment for block programming; safe and healthy working with computers.

Implementation of the computer models in visual environment could be prepared by: unplugged activities with visual materials – mosaic, jigsaw etc.; working in simulation environment; performing algorithms in programming environment; use of easy for handling robotic devices; etc.

Key concepts are digital device, user, user name, user password, algorithm, code, command, loop, menu, button, animation, animated image, slide, information and data, branching, random number, variable, arithmetic and logical operators, conditions.

#### C. Challenges and problems with implementation of the curricula

As every new entity the new school subject and curricula set challenges and problems in front of all stakeholders – teachers, parents, students, etc.

- Providing enough prepared teachers with relevant competency to teach the new subject in primary school. According to the state documents the subject has to be taught by primary school teachers, regardless of their qualification in ICT.
- Choice of appropriate programming environment. The environment has to provide conditions for implementation of the curricula. It should be based on block programming and to be free for the schools and students.
- The syllabuses include a lot of abstract concepts like algorithm, loops, branching, variables, digital identity etc. These concepts have to be precisely defined and in the same time to be explored in accessible manner for the 9-10-year-old students.
- Implementation of basic concepts in block programming environment and main topics of the syllabus requires usage of concepts that are part of mathematics curricula in next grades - negative numbers, coordinates and coordinate system, measurement of angles in degrees, random number.

### IV. SOME DIDACTICAL APPROACHES FOR IMPLEMENTATION OF THE CURRICULA

One of the challenges for implementation of the curricula is abstraction of the concepts. For Introduction of the concepts could be applied adequate pedagogical methods and tools as:

- Show of objects with illustration of the concepts.

- Indication of properties of concepts.
- Use of analogies and examples from everyday life.
- Use of fun elements - challenges, riddles, anecdotes, puzzles.
- Use of computer educational games, simulations or demonstrations.
- Interactive tests and an electronic textbook.
- Use of unplugged activities.
- Problem solving.
- Experiments with “backed” (prepared in advance by teachers) and “half backed” codes.

Another challenge is choosing programming environment for implementation of curricula in primary schools. Most of schools have chosen the popular environment Scratch (scratch.mit.edu) due to its intuitive interface, well established community of teachers and other users, localization in many languages, guides for teachers and students.

Aside from well-known real-life algorithms for preparing of sandwiches, doing gymnastic or dancing, for the illustration of loop algorithm algorithms from known tales could also be used.

Example 1: Algorithm from tales

Cinderella – Find Cinderella

1. Find a girl;
2. Try the shoe
3. If the shoe fits, then Cinderella is found, in other case go to step 1.

This example illustrates one of the constructions in programming languages - loop with post condition.

Example 2: Unplugged game activity for digital devices.

In the table are hidden the names of 3 digital devices. Find them. Which are their common elements?

a	l	t	o	p	a	r	i	s	a
s	m	a	r	t	p	h	o	n	e
s	i	b	g	o	a	l	r	o	w
e	a	l	a	p	t	o	p	r	i
t	m	e	m	i	r	a	n	d	y
o	p	t	e	c	o	d	a	n	c

Example 3: Unplugged activity. Find of words in the grid integrates Math, Computer science (Informatics).


1. Find the two-digit numbers with equal digit.
2. Order them in ascending order.
3. Replace the numbers with relevant alphabet sign.
4. Which word do you obtain?

5. Explain how to use it?

34-m	11-P	43-n	25-F	12-b	31-G
43-n	22-a	33-s	33-s	13-c	12-b
21-l	12-b	21-l	44-w	13-c	13-c
23-E	13-c	23-E	55-o	66-r	77-d
13-c	25-F	43-n	23-E	13-c	25-F

To avoid the problem with coordinate system and negative numbers when sprites have to be positioned, it is suitable to use direct manipulation of the sprite, colors for different quadrants [6], experiments and discussion.

Example 4: Use colors to explain coordinate system. This idea was given by prof. Ivan Kalas from Comenius University, Bratislava during a training workshop.

The students work with “half baked” file with colored quadrants in coordinate system as a stage and one sprite (cat). The first task is to move the cat in differently colored areas and to observe the numbers changing in block  block.

After experiment with direct manipulation teacher or students can do conclusions about use of sign minus, without explanation about negative numbers. The concept about negative numbers is part of 5<sup>th</sup> grade math curricula. In this way the teacher can do propedeutics of negative numbers and coordinate system and coordinates that are part from 6<sup>th</sup> grade mathematics curriculum.

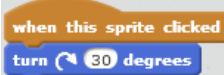
A similar situation occurs when students have to use blocks for turn



Measurement of the angles is part of 4th grade Math curricula. To reduce level of abstraction, it is suitable to use experiment with clock. The teacher can explain that when the hour arrow is turned from 12 to 1 o'clock it makes an angle from 30 degrees.

Example 5: The task is:

Use file clock.sb2. (Figure 1.) Click on the green flag and after that on the red arrow. What happens? Look at the code. Which new commands are used? Start file again and click 3 times on the red arrow. Which number will

show the arrow? In the code  change number 30 to 60, 90, 15. After every change start code and observe which number shows the arrow.

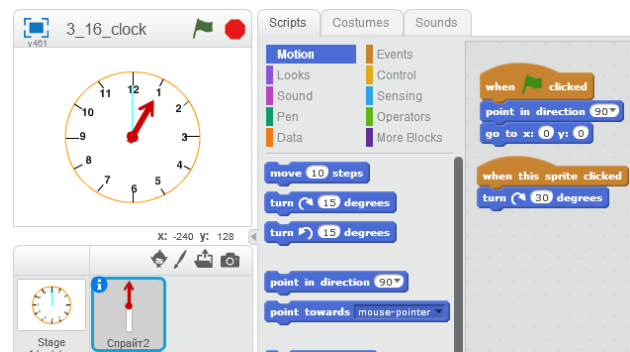


Figure 1. Clock experiment

In this way students will have visual performance of abstraction for angle's metrics.

Example 4 and Example 5 give also a good propaedeutic of math concepts.

Example 6: Use of experiment to involve concept animation. The task is presented in [9].

Open file pinokio.sb2 (Figure 2). Click on the green flag. What kind of activities is Pinocchio performing? See costumes and click on the costumes. What happens? Check the code. Do you find motion blocks?

After this experiment, teachers could involve easy concept animation as a quick change of images.

Experiments at different levels of object controlling help students to better understand concepts and principles of programming.

Example 7:

Along with the experimental work teachers can use tasks that could be enlarged step by step. The example of set of extended tasks is performed in [9]. In the ground of the task is the tale "The Gigantic Turnip".

This is a folklore tale with six characters – grandfather, grandmother, granddaughter, dog, cat and

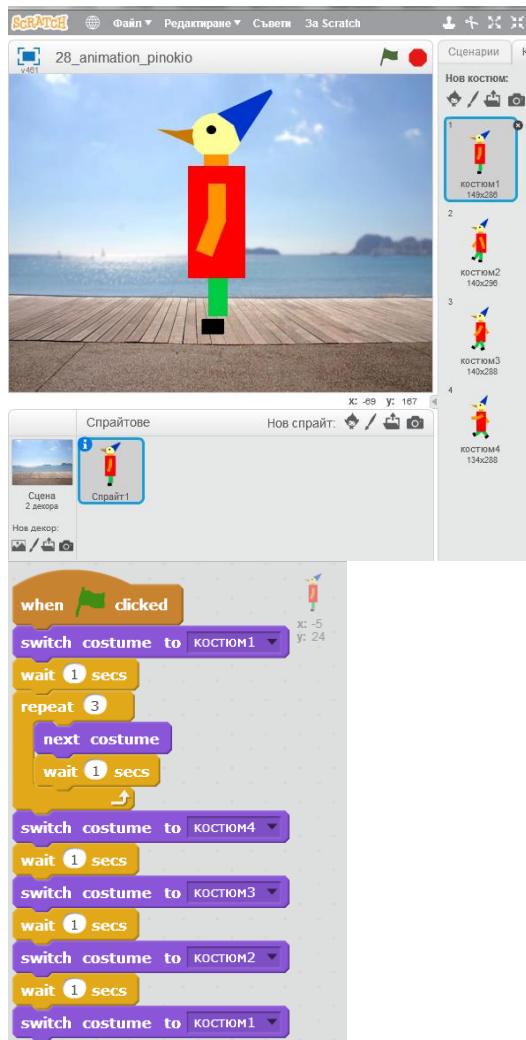


Figure 2. Animation experiment [9]

mouse. The grandfather plants a turnip. The turnip grows so big and the grandfather cannot pull it. He thinks: "I have to call grandmother to help me." He calls grandmother and together they try to pull the turnip. They still don't succeed. Grandmother thinks: "I have to call granddaughter." She calls the granddaughter and once again they all together try to pull the turnip, but still unsuccessfully. The granddaughter thinks: "I have to call my dog". She calls the dog. The dog comes. All together they try to pull the turnip. Again they cannot pull it. Dog thinks: "I have to call the cat." The dog calls the cat and cat comes. All together they try to pull the turnip. Again the try is without success. The cat thinks: "I have to call the mouse." The cat calls the mouse. The mouse comes. At the end they all together pull the turnip.

This tale is well-known by the students. When students learn about algorithms they use interactive micro game to order heroes in the tale (Figure 3).

When students explore Scratch programming environment they can step by step:

- develop stage backdrops;
- use "half backed" file for experiments and observation of code and behavior of part of sprites;
- continue scenario description and implementation;
- implement story telling with costumes changing, events driving with broadcasts (Figure 4.).

The teacher can use slide with codes of grandfather, grandmother and granddaughter. With the help of this slide, similarities and differences could be discussed.

## V. CONCLUSION

Teaching computer programming in primary schools has many challenges, some of which are outlined and discussed in the paper.

The new school subject was brought to Bulgarian school curricula in the current 2018/2019 school year. There are a lot of challenges in the process of implementation of the curricula. These challenges could be solved with the use of an adequate teaching methods, grounded on the constructionism, with selection of



Figure 3. Micro game for ordering characters from the tale "Gigantic Turnip" [9]

appropriate tasks – close to the students’ everyday practice and their interests. The tasks have to be fun and in the same time help students develop algorithmic thinking and achieve the desired learning outcomes.

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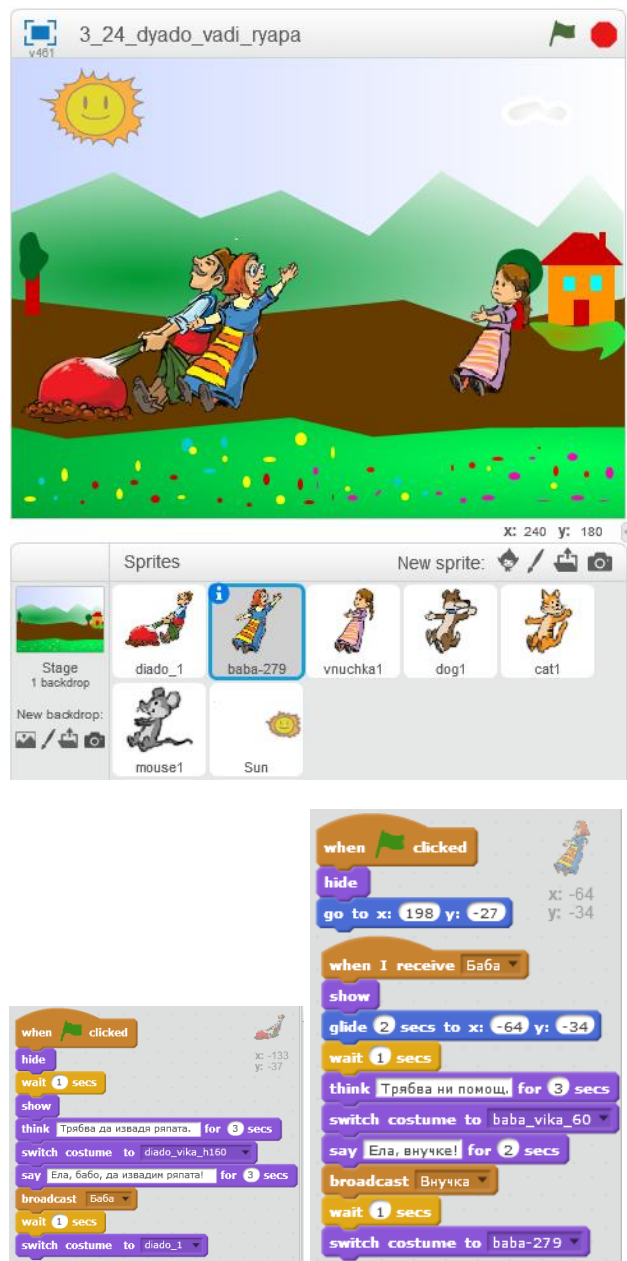


Figure 4. The tale “The Gigantic Turnip” [9]