CREATING TEACHING AIDS AIMED AT DEVELOPING COMPUTATIONAL THINKING

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Abstract
Since we live in a digital age, many (not only educational) institutions, from kindergartens to universities, use digital technology (touch screen devices, interactive whiteboards, robotic technology), creating an opportunity to incorporate this technology into elementary and pre-school education and use it to help children develop basic digital competencies such as information and data literacy, communication and cooperation, problem-solving skills and computational and algorithmic thinking. The main curriculum documents for all educational levels (i.e. for pre-school, primary and secondary education) are constantly being updated, with the topics of digital literacy and digital competencies becoming more and more relevant. Technology makes it easier to develop these competencies through the use of didactic games and involuntary learning. Developing computational and algorithmic thinking from an early age (starting in kindergarten and continuing in elementary school) is key to being successful in the next stages of life – from further education to personal life. Problem-solving skills, logical and abstract thinking, creativity and originality are the most appreciated skills today. The paper introduces activities for various primary school subjects, which use the ever more popular robotic toy Bee-Bot to help children develop the aforementioned competencies.

Keywords: computational thinking, digital literacy, digital competencies, Bee-Bot.

1 INTRODUCTION
Modern technology – tablets, iPads, smartphones, various applications, programs and robots – have become an integral part of our everyday lives. In fact, they have become so important that we cannot imagine a life without them. They make our work easier, help us organize and plan. And while they have a didactic function, they also allow us to relax and have fun. It is the teacher’s task to use these tools properly in instruction. Even though modern technology cannot fully replace the teacher, it can be of invaluable help to them when used properly.

In order to be able to use technology in elementary school instruction, teachers need to be familiar with it. If the teacher is not able to use technology in an effective manner, they cannot possibly incorporate computational and algorithmic elements into instruction and help children develop their digital competencies. That is why the TPCK model should be mentioned. In the beginning, there was Shulman’s theory that defined the so-called PCK (Pedagogical Content Knowledge). It is based on the notion that professional content should be taught together with methods suitable for teaching a particular curriculum. The development of technology made this model popular. Mishra and Koehler expanded it by adding a technological aspect, thus creating TPCK (Technological Pedagogical Content Knowledge) [1].

The model defines today’s teacher who should not only be an expert in their field, but who should also use appropriate didactic and methodical approaches and be able to incorporate technological elements into them. A pre-school teacher should be a college graduate who is familiar with pre-school education methodology and didactics. Moreover, they should also understand children’s psychology, development and behavior, and also be able to sing, lecture, read fairy tales to children, etc. The teacher should also be technologically educated, i.e. able to use basic technological equipment such as the computer, mobile phone, Internet. In elementary school these tools could be effectively used to help develop perceptual skills, transparency, etc.

2 TECHNOLOGY AND EDUCATION
The Czech school system has been changing for a number of years now. Up until 2004, the Education Act of 1984 and the Act on School Facilities of 1978 were in effect. The major change came in 2005 when the acts on pre-school, elementary, secondary, higher professional and other education were adopted. Among other things, the new acts introduced new curriculum documents. A lot has changed
since those acts were adopted. Since modern technology has changed the entire way of life, it is necessary to also change education in order to allow future generations to live full lives and find their place in the world [2]. Today, there are two main curriculum documents which represent two levels of education in the Czech Republic. The first level is represented by a national document called The Framework Education Program (FEP) while the second level is represented by a school level document called the School Education Program (SEP). Each school designs its own School Education Program, which is based on the Framework Education Program for the particular educational stage [3].

Since the Czech education system tries to keep up with the latest digital technology trends and developments, the document titled Strategy for Education Policy of the Czech Republic Until 2020 was published in November 2014. This document is aimed at the gradual incorporation of modern technology into all subjects. It describes the current situation and introduces both the idea of digital education and its goals. Moreover, the Strategy also defines three cross-cutting priorities: reducing inequality in education; high-quality instruction with the teacher being the key element; responsible and effective management of the education system. New technology makes educational resources available to all students, without exception. However, not all students have the same possibilities (e.g. they come from different socio-economic backgrounds, etc.). Therefore, it is necessary to minimize differences between students and allow them all to develop their digital literacy and computational thinking [4].

The Strategy wants education to be open to new teaching methods which make use of digital technology. Moreover, it also aims to improve students’ competencies related to information management and the use of digital technology and help them develop computational thinking.

2.1 Bee-Bot

Bee-Bot is a programmable robotic toy, an interactive digital tool for developing logical thinking, spatial imagination, planning and pre-mathematical concepts (Figure 1). It appears to be a perfect tool for developing computational thinking and basics of programming, informatics and mathematics.

![Figure 1. Bee-Bot and Card Mat.](image)

Bee-Bot works by remembering and storing individual steps/commands in the order chosen by the user. Children are immediately faced with abstraction as the toy does not have a display or screen on which they could see the selected commands. Therefore, it is important to plan the individual commands in advance (e.g. using a worksheet). The upward arrow allows us to make the bee move forward by 15 centimeters (forward means in the direction of the bee’s eyes). The downward arrow allows us to make the bee move backward by 15 centimeters (backward means in the direction of the bee’s “buttocks”). The right/left arrow makes the bee turn 90 degrees to the right/left while the “X” button is used to delete the commands stored in the bee’s memory. Children should keep this in mind to make the bee carry out only the current commands, and not the past ones. The “II” button is used to stop the toy during the execution of a command. The “GO” button starts the bee and makes it execute the proposed sequence of commands. When creating Bee-Bot activities, the teacher should use a card mat with 15x15cm squares. It is entirely up to the teacher how many squares there will be. If the card mat is transparent, the teacher can put pictures under the individual squares, creating obstacles and/or stops on the bee’s way.

3 PROPOSED ACTIVITIES

These activities are aimed at developing children’s learning, social, personal and professional competencies. Children will learn how to use commands to achieve the expected result, determine
and justify the sequence of commands and understand that if they change the sequence of commands, they might not be able to reach the finish line (i.e. to solve the problem). Moreover, they will also learn how to control a programmable toy, developing their digital literacy and competencies in a natural way.

Problems that may occur are related either to children’s not knowing how to properly control the programmable toy (e.g. unfamiliarity with the arrow symbol or a lack of spatial orientation – to the left/right) or not being familiar with the curriculum at which the proposed activities are aimed.

3.1 Spelling

In curriculum documents:
- Educational area – Language and language communication
- Study program – Communication and language education
- 1st year of elementary school

Required tools:
- Programmable toy
- 90x105cm transparent card mat with 15x15cm squares
- 90x105cm alphabet sheet (Czech alphabet which has 42 signs) with 15x15cm squares; there is one sign in each square
- Worksheet

The activity is aimed at spelling out words (names, simple words) and combining letters and syllables into words.

Activity: The teacher divides the children into smaller groups (of 3 or 4), with each group having their own transparent card mat, alphabet sheet (Figure 2), programmable toy and worksheet. The programmable toy starts from the START square. Children’s task is to program the robotic toy to spell out the name of the selected pupil. To do so, they can use the aforementioned worksheet (Figure 3), in which they can write a program using arrow symbols. Only then can they program the toy, making sure that it is spelling out the name correctly.

The activity can be modified by changing the task, e.g. to write a program which would make the robotic toy go from START to the letter Ň and then to the letter CH, using only the Back command. Moreover, this activity can include any topic – favorite school subject, meal, color, etc.

![Figure 2. Transparent Card Mat and Alphabet Sheet.](image)
3.2 Traveling Across Europe

In curriculum documents:

- Educational area – Man and His World
- Study program – The Place Where We Live
- 5th year of elementary school

Required tools:

- Programmable toy
- 90x105cm transparent card mat with 15x15cm squares
- 90x105cm alphabet sheet (Czech alphabet which has 42 signs) with 15x15cm squares; there is one sign in each square
- Worksheet
- Quiz cards

The activity is aimed at consolidating knowledge about the Czech Republic’s neighboring countries.

Activity: The teacher divides the children into smaller groups (of 3 or 4), with each group having their own transparent card mat, alphabet sheet (Figure 2), programmable toy and worksheet. The programmable toy starts from the START square. Each group picks a quiz question (Figure 4). They can use the aforementioned worksheet (Figure 3) to write a program (using arrow symbols) which would make the toy spell out the correct answer. Only then can they program the toy, making sure that it is spelling out the answer correctly.

The activity can include any topic. Moreover, it also allows students to create their own quiz questions. Any sheet (e.g. image sheet) can be placed under the transparent card mat – the country’s typical buildings, famous people, traditional food, etc.

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Question 1
What is the name of the capital of Slovakia?

Question 2
A river flows through Austria from west to east?

Question 3
What language is spoken in Poland?
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Figure 4. Quiz Cards.
3.3 Practicing Arithmetic

In curriculum documents:
- Educational area – Mathematics and Its Application
- Study program – Number and Arithmetic Operations
- 2nd year of elementary school

Required tools:
- Programmable toy
- 60x60cm paper card mat with 15x15cm squares
- Dice
- Worksheet

The activity is aimed at becoming acquainted with mathematic operations (+, -, =), addition and subtraction to 20.

Activity: The teacher divides the children into smaller groups (of 3 or 4), with each group having their own paper card mat, programmable toy and worksheet. Each group’s task is to write numbers from 2 to 17 in any order on the paper card (Figure 5). The teacher determines the programmable toy’s starting point. Then they roll the dice four times in a row, writing the number on the blackboard. The groups’ task is to add the first three numbers then subtract the fourth and come up with a result. They perform all the operations in the worksheet first (Figure 6). Then each group programs the programmable toy’s way from its starting point to finish (the result).

The activity can include numerous operations with numbers from 1 to 40 – the teacher rolls the dice eight times, with the task being to add the first seven numbers and then subtract the eighth.

<table>
<thead>
<tr>
<th>1. number</th>
<th>Addition 2. number</th>
<th>Addition 3. number</th>
<th>Subtraction 4. number</th>
<th>Equals Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>-</td>
<td>=</td>
<td></td>
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<tr>
<td>+</td>
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<td>+</td>
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</tbody>
</table>

Figure 5. Numbers Written on Paper Card.

Figure 6. Worksheet.

3.4 Solar System Planets

In curriculum documents:
- Educational area – Man and Nature
- Study program – Physics – Space
Required tools:

- Programmable toy
- 75x75cm transparent card mat with 15x15cm squares
- 15x15cm image cards with pictures of the planets in the Solar System
- Worksheet

The activity is aimed at becoming acquainted with the planets in the Solar System, their position from the Sun and creating a model following instructions.

Activity: The teacher divides the children into smaller groups (of 3 or 4), with each group having their own transparent card mat, image cards, programmable toy and worksheet. The teacher places the pictures of the planets (in a random order) under the transparent mat (Figure 7). Children’s first task is to name the planets on the cards. Then they need to determine their position from the Sun. They start with the planet which is closest to the Sun (which will also be the programmable toy’s starting point). They can use the aforementioned worksheet, in which they can write a program (using arrow symbols) which would allow them to explore the Solar System, from the planet that is closest to the Sun to the one that is farthest from the Sun (Figure 8). Only then can they program the toy, making sure that the order of planets is correct.

The activity can be modified by reversing the order of planets – the programmable toy would start from the planet which is the farthest from the Sun; or searching for planets with particular features – the largest, the densest, the coldest, the planet with a ring, etc.

4 CONCLUSION

The incorporation of mobile technology into everyday activities has changed people’s view of the world. If we want to live in the digital world, we need to be able to use digital technology in an effective way. Introducing activities for developing algorithmic thinking, solving problems based on real life situations and using technology at an early age can help prepare children for the next stages in life. A
teacher, who can use digital technology and applications, will be able to present the curriculum to
students in an appropriate manner, helping them achieve the desired outcomes and develop key
competencies in accordance with the established concept.

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