COMPUTATIONAL THINKING – COULD WE BRING IT TO HUNGARIAN EDUCATION?

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Abstract: Computational thinking has become a popular term in the recent 8-10 years: many researchers and educators have tried to give a definition of computational thinking, several university institutions have started to give courses in computational thinking, and quite a few countries have made an attempt to make computational thinking part of their curriculum. Today, one can hear a lot about AP Computer Science Principles and the online courses built upon it. Their aims are to improve secondary school students' general problems solving abilities, develop their creative thinking, and in general to prepare students for a world where computational thinking is a requirement. It is no question that these aims are desired in Hungary, as well. What can we learn from these attempts, and how could the Hungarian informatics education make a step towards those aims?

Key words: computational thinking, informatics education, AP Computer Science Principles, curriculum

1 Introduction

The term computational thinking came forward in educational discussion in 2006 when Jeannette M. Wing gave a definition for this term. [8] In 2010, she redefined her original version, and wrote that "Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent." [9] Her definition is widely used now in academic papers; however, many researchers have tried to find their own definitions in the past few years. As Wing wrote 10 years after her original paper, "computational thinking will be a fundamental skill used by everyone in the world by the middle of the 21st century. By fundamental, I mean as fundamental as reading, writing and arithmetic." [10] If this is true, education does not have much time to adapt to these future needs.

2 Bringing computational thinking into education

Several countries have started to deal with the problem of students' lacking the skill of computational thinking that is now thought to be vital for future success. The United Kingdom answered this need by making computer science an obligatory subject at K-12 level starting from September 2014. Their national curriculum states that "a high quality computing education equips pupils to use computational thinking and creativity to understand and change the world."[4] Poland introduced a new computer science curriculum starting from the 2015/2016 school year, with the aim of teaching computer science to everyone, and putting emphasis on computational thinking instead of ICT skills. [6] At the beginning of 2016, the US President, Barack Obama announced the Computer Science for All initiative, and several agencies are dedicated to improve K-12 computer science education. For example, the National Science Foundation funded the development of two new computer science high school courses, namely Exploring Computer Science and AP Computer Science Principles. [5] Moreover, students can prepare for the AP CS Principles exam via online courses and syllabuses provided by such providers as Code.org, EDX or CodeHS, which also provide assistance to secondary school teachers.[1] Code.org,

for example, offers detailed lesson plans, for unplugged and/or computer-aided lessons of 45-50 minutes with tips for teachers, challenges and more.[2]

Although in Hungary Informatics is an obligatory subject in primary and secondary schools, the focus is mainly on information and communication technologies and software applications, while algorithmic thinking and programming get less emphasis. Moreover, the curriculum frameworks introduced together with the National Curriculum in 2012 drastically reduced the number of Informatics lessons. The advanced level Informatics school leaving exam entails a programming task, but few students choose this level of exam. The government has recently announced a new National Curriculum together with new curriculum frameworks for each subject, which will be introduced in 2018. What aspects of computational thinking are already part of the curriculum, and what should be modified so that education could equip Hungarian students with the knowledge necessary in the future? As AP Computer Science Principles (AP CSP) is based on the ideas of computational thinking, and it is embraced by several institutions, this paper will take it as the basis of comparison with the current Hungarian curriculum.

3 Objectives and content

The AP CSP curriculum is based on seven big ideas around which the areas of study are organized; and six computational thinking practices (connecting computing, creating computational artifacts, abstracting, analysing problems and artifacts, communicating, collaboration). These provide the framework for the list of learning objectives.

The Hungarian National Curriculum lays the basis for the subject of Informatics in the description of the Digital competence, which it defines as a key competence, and in the detailed description of the Informatics subject area. The description emphasizes the importance of information-processing; using communication technologies; using computer applications for word processing, data storage, presentation making and creating multimedia content; logical and algorithmic thinking and problem solving; and information society. Moreover, the general description of key competences lists critical thinking, creativity, problem solving and collaboration as skills that should be developed in every subject area. The description of the area of digital competence states that students should understand how ICT skills help in creativity and innovation, and they should be able to use ICT skills in critical thinking, creativity and innovation. [7]

The Abstraction topic of the AP CSP course's learning objectives all occur somewhere in the Hungarian curriculum. Students are expected to "describe the variety of abstractions used to represent data; explain how binary sequences are used to represent digital data; develop an abstraction when writing a program or creating other computational artifacts; use multiple levels of abstraction to write programs; identify multiple levels of abstractions that are used when writing programs; and use models and simulations to formulate, refine and test hypotheses". The Algorithm topic also includes common objectives, which include developing an algorithm for implementation in a program and expressing an algorithm in a language. As AP CSP places more emphasis on the levels of analysing, evaluating and creating of Bloom's taxonomy, it also asks for the evaluation of algorithms analytically and empirically, for efficiency, correctness and clarity, and it deals with more complex concepts such as explaining the differences between algorithms that run in a reasonable and those that do not run in a reasonable time, and mentions that there are solvable, unsolvable and undecidable problems. The learning objectives of the Programming topic, among which one can find development of a correct program to solve problems or collaboration to develop a program, also all appear in the Hungarian curriculum.

The AP CSP course deals with the topic of Internet (how the Internet functions, how the characteristics of the Internet influence the systems built on it, cybersecurity concerns) and the topic of Global impact (how computing enables innovation, beneficial and harmful effects of computing, computing and real-world contexts) in more detail than the Hungarian curriculum. The topic of Data and Information is approached differently: the AP CSP concentrates more on big data, the visualisation and analysis of data, while the Hungarian curriculum introduces students to the world of databases and manipulation of data in spreadsheets.

The AP CSP course does not aim to deal with software applications such as word processing, creating and using spreadsheets and using presentation software, which take up a huge percent of the Hungarian Informatics curriculum. On the other hand, AP CSP dedicates a whole topic to creativity, which appears as an aim in the National Curriculum as well, but no learning objective is assigned to it in the detailed Informatics subject description.

4 Timing and teaching methods

Based on the above description, one could think that the Hungarian education system is mostly in alignment with the ideas of computational thinking and future needs. The problem is that the National Curriculum and the curriculum frameworks for each subject do not seem to match. Concentrating on the Informatics subject, the words „creativity" and "innovation" do occur in connection with choosing the right applications to solve different problems, but the overall framework does not seem to give space to creative and innovative achievements due to lack of time. For example, for the "Problem solving with informatics applications and methods" topic only 20 (out of 106) lessons is dedicated in primary school, and 8 (out of 72) lessons in secondary school. Of course, problem solving normally occurs outside the "programming classes" as well, but the time constraints of a huge subject material do not foster it. As a result, many teachers aim for preparing their students just for the different ECDL modules and/or the normal level Informatics exam.

AP CSP, contrastingly, is just a one semester course for secondary school students with at least 90-120 hours of lessons, from which 20 hours should be taken up by two performance tasks for assessment reasons. As there is more time to deal with computational thinking phenomena, problem solving, creative thinking, abstract thinking are more likely to occur in practice, not just among the learning objectives. There is also more space in the classroom for cooperative and innovative methods of instruction, such as pair programming, online/offline group work, project based learning etc. The AP CSP course description explicitly asks for these king of instruction methods.

5 Assessment

What is really different in the Hungarian Informatics subject and the AP CSP course is the assessment of students at the end of their studies. Neither are obligatory for secondary school students, though. The AP CSP course is just an optional course for students, while the Hungarian school leaving exam in Informatics is not an obligatory exam. The AP CSP appropriately assesses students with two in class performance tasks that ask for using creativity and being innovative (where the second performance task could be a collaborative project), and a multiple-choice type of written exam, where the questions measure abstract and algorithmic thinking abilities and problem solving skills, besides questions that inexplicitly measure content knowledge. The Hungarian school leaving exam at the basic level, however, does not even include an algorithmic thinking or programming part. Programming tasks only appear at the advanced level exam. This is a contradiction to

the aims of the curriculum, where problem solving is emphasized. Moreover, creativity, critical thinking, innovation or collaboration is not part of the exam, reproduction and application of learnt knowledge are expected for most of the time.

6 What to do

Based on the analysis of the Hungarian National Curriculum one can see that the potential of preparing students for a world where computational thinking is a basic skill is given. The problem is with the contradiction of the aims of curriculum and the things that happen in the Informatics classroom. There is not enough time to develop computational thinking skills with the traditional teaching methods when there is a huge amount of material to be covered. So either there should be a higher number of Informatics lessons, or ICT and Informatics should be two different subjects, or teachers should apply non-traditional teaching methods more, or all of these together. It should not be an aim to train students to Trial-and-Error Wizard based computer users [3], who do not even realize that the solution they had produced is not the solution to the given problem.

How could teachers gain time for their aims if no increase of the number of lessons could be seen? In that case, you can only gain time by not loosing time. This means students should be made motivated to learn the subject area, contribute to the classroom events to a huge degree. One should also make students responsible for their own learning. Today, gamification is a buzzword that could be a solution to some classrooms. Other options are the flipped classroom where more active and collaborative learning can take place during the lessons, project based learning can also be used in several cases. The teacher should apply ideas from the amazing materials available in the online courses of AP CSP related classes, such as unplugged lessons, pre-designed app labs, handouts, readings, videos, etc.

Moreover, the assessment should be reconsidered so that students could really show their skills in the field of computational thinking while demonstrating creativity, innovation, critical thinking and problem solving abilities with the use of differenct ICT tools. A portfolio of former artifacts and projects, a seperate written examinaton testing for the concepts appearing in the learning objectives are all possible ways.

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