COMPUTATIONAL THINKING IN EDUCATION

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Abstract: One of the most important issues in education: What to teach? What is the main ability which helps students for a successful career in a rapidly changing world? Searching the answer we will meet the concept of computational thinking, which is recently a key concept in informatics. The paper gives an overview of the computational thinking and how to improve this skill through education.

Key words: computational thinking, definition, informatics education, multidisciplinary education, teacher education

1 Introduction

The main topic in this paper is the concept of computational thinking. It contains two major parts. In the first part I examined the development of the computational thinking definition in last 10 years. When formed this term, what does it mean, how it is changed etc.? In the second part I asked important questions about the relationship between computational thinking and education. Finally I tried to find the answers, and looking for further research opportunities.

2 The development of the definition

Jeannette M. Wing was the first who used the computational thinking term in 2006. [2] She highlighted that computational thinking is a fundamental skill for everyone, not just for computer scientists. Same way as reading, writing and arithmetic every child should learn computational thinking, because it's as important as other fundamental skills.

In her first definition states that computational thinking is using abstraction and decomposition. Furthermore she declared that computation thinking is:

- Conceptualizing, not programming.
- Fundamental, not rote skill.
- A way that humans, not computers, think.
- Complements and combines mathematical and engineering thinking.
- Ideas, not artifacts.
- For everyone, everywhere.

In 2008 she said the essence of computational thinking is using abstraction [3] and formed the 3A definition: abstraction, automation and analyzation.

And the first exact definition was born in 2010: "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." [4]

She highlighted again that computational thinking is very important not only for computer scientists, but also in other disciplines and daily life. For example this helps to be able to understand what parts of a problem solvable by computing, what opportunities and constraints has the computational tools, how can apply and adapt a computational tool and create something new.

Later Cynthia C. Selby and John Woollard made a deep survey about papers in this topic and they proposed the following definition [1]:

"Computational thinking is an activity, often product oriented, associated with, but not limited to, problem solving. It is a cognitive or thought process that reflects

- the ability to think in abstractions,
- the ability to think in terms of decomposition,
- the ability to think algorithmically,
- the ability to think in terms of evaluations, and
- the ability to think in generalizations."

They included these terms, because found consensus in the literature or well-defined across multiple disciplines. Furthermore they excluded terms like logical thinking, problem solving because these are too broad terms. And also excluded for example automation, modelling and simulation because evidences the use of skills.

3 Computational thinking in 2016

In 2016 Wing evaluated what happened in last 10 years: much more than she expected. [5] Now, widely accepted that computational thinking is important not only for computer scientist, but everybody. That's why computational thinking worldwide appeared in K-12 education. These courses are not programming courses, but focus on the essence of computer science.

It shows that computing is appeared in United Kingdom's education in K-12 level from September 2014. Furthermore one million BBC micro:bit will be distributed free for every 11-12 year-old student and their teachers. In 2013 started code.org as a non-profit organization to providing access to computer science education to all. Similar efforts are experienced in Australia, Israel, Singapore and South Korea.

The importance of it can be seen as Barack Obama, the president of the United States in January 2016 announced an enormous funding for computer science education. This initiative includes to train at least 9000 high school teachers to teach computer science and integrate computational thinking into their curriculum.

Furthermore she said there is an analogy to mathematics. We know what we teach in each class, there is a progress. What about computer science? When is it the best to teach recursion or algorithm? These are the current issues nowadays.

4 Important questions in computational thinking education

As Wing highlighted in every paper computational thinking skill isn't limited to computer scientists, but everyone needs it for daily life, effective work, and other disciplines. There are some important questions about computational thinking's place in the education.

Is computational thinking well-defined?

There is a long way to build an exact definition for a really complex concept (see mathematics). Although there isn't an unitary definition, but it has a quite big literature, and everybody thinking something similar. And that is more than enough to see it's a very important and fundamental skill in the 21st century, so obviously it had to be part of education. That's why I think isn't so important the exact definition.

Which subject has to develop computational thinking?

Computational thinking should be taught in informatics and other subjects also. In informatics lesson students learn a lot of tools and mentality, core concept of computer science. So informatics highly suitable for effective development of computational thinking, but not limited to informatics only. It's important to merge computer science and computational thinking, because latter is important for everyone, for every employee (for

example scheduling tasks, learning to use new tools or applications). So it would be important that computational thinking appear in other subjects. For example use it for measurements and simulations in physics or chemistry. It's also important, because the scientists process huge amounts of data by computer, so good to see it in science lessons.

Where is the right place in public education or higher education?

Continuing the previous idea, a good quality public education is the basis, it is absolutely necessary, achieving that develop computational thinking to everyone, independently the further education. So the main field is public education, but higher education builds on it discipline specific knowledges which improves and complements the skill. For example nowadays natural science researchers often use computer simulations that can be substitute expensive experiments. So they often have to think as a computer scientist during their research. And it is easier if they have the appropriate funds from the secondary school.

But now it's just a hope, until the students don't take computational thinking skills during their public education it is necessary to teach them at the university. And the teachers also need further training to speed up this progress and computational thinking integrates to public education as soon as possible.

Is it necessary a computational thinking course in teacher education?

In my opinion, it would be essential a computational thinking course to everyone in teacher education. Future teachers have to improve this skill in their students, so they have to learn about it. Computational thinking will be very important in daily life, so teachers have to improve it independently from the subject. As I mentioned computer science is highly suitable for improve this skill, therefore this course is more important for informatics teachers.

Conclusion

Computational thinking is a complex concept which definition evolves for 10 years, but there is still no uniform definition. And it has a big literature and in general there is an agreement what is it.

In 2016 it is a really current concept worldwide. It has important role every country where reforms informatics education. It is clearly important, but computational thinking's methodology is really hard, because it is not facts and data which can be learnt, but a mentality. That's why so difficult to make a curriculum, especially not necessarily connected to a specified subject. But the problem is recognized and these curriculums are under development.

First of all teachers need to learn this mentality, this way of thinking and confidently use the computer. It is necessary to hold further trainings for informatics and other subject teachers also. Furthermore build in the teacher education to next generations' computational thinking skills are getting better.

Computational thinking will be increasingly important in the 21st century people's lives. As Seymour Papert (co-founder of MIT's Artificial Intelligence Lab, and the MIT Media Lab.) said:

"Success in the slowly changing worlds of past centuries came from being able to *do well what you were taught to do*. Success in the rapidly changing world of the future depends on being able to *do well what you were not taught to do*."

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