Computational Thinking – Bebras Style

Valentina Dagienė, valentina.dagiene@mif.vu.lt

Vilnius University, Lithuania
My talk about

- What is Computational Thinking
- Components of Computational Thinking
- UK model: Concepts and Approaches
- Future PISA 2021 and Computational Thinking
- What is Bebras?
- The Bebras tasks – many examples
- The Bebras game cards
Why we need to teach CT?
INTEGRATION CT-STEAM!
Computing education – shifts in approach

- 2018: Integration Computational Thinking to Digital competencies
- 2012: Deepening Computing education
- 2006: Involving Computational Thinking
- 2000: Fluency with ICT
- 1990: ICT era – Computer Literacy
- 1980: Programming – coding
- 1970: Teaching about computer and algorithms
Computational Thinking

- Originally used by Seymour Papert, MIT, in *Mindstorms: Children, computers, and powerful ideas*
Computational Thinking

Popularized by Jeanette M. Wing in 2006

„Computational thinking involves solving problems, designing systems, and understanding human behaviour, by drawing on the concepts fundamental to computer science“

„an universally applicable attitude and skill set everyone, not just computer scientist, would be eager to learn and use“


„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“

CT – Terminology
CT for Computational World

Abstraction

Problem Formulation

"how does a mudslide work?"

Analysis

Solution Execution and Evaluation

human abilities

computer affordances

Automation

Solution Expression

visualize the consequence of thinking

build simple model of gravity
CT Key Components

- Decomposition
- Algorithm
- Computational Thinking: Key Concepts
- Pattern Recognition
- Abstraction

https://cspathshala.org/2017/10/25/computational-thinking-curriculum
Google have gathered a huge amount of resources and articles about CT: https://edu.google.com/resources/programs/exploring-computational-thinking

- Many publications on CT
- Googlescholar: 1 930 000 publications (2020/06)
- Kalelioglu, etc. have analyzed 125 papers (2016)

Developing Computational Thinking in Compulsory Education - Implications for policy and practice

Abstract:
In the past decade, Computational Thinking (CT) and related concepts (e.g., coding, programming, algorithmic thinking) have received increasing attention in the educational field. This has given rise to a large amount of academic and grey literature, and also numerous public and private implementation initiatives. Despite this widespread interest, successful CT integration in compulsory education still faces unresolved issues and challenges. This report provides a comprehensive
The Computational Thinking Study

Computational thinking (CT) is a shorthand for "thinking as a computer scientist", i.e. the ability to use the concepts of computer science to formulate and solve problems. Computational thinking has been promoted in recent years as a skill or competence that is as fundamental as numeracy and literacy. Despite the high interest in developing CT among schoolchildren and the large public and private investment in CT initiatives, there are a number of issues and challenges for the integration of CT in the school curricula.

More evidence-based research is needed to gain further understanding on the following aspects:

- How can we define CT as a key 21st century competence for schoolchildren?
CT and related terminology

- **Emphasis on a particular aspect of CT** (e.g. “Algorithmic thinking” captures the spirit of computing, the art of computing)
- **Stakeholders’ acceptance and preference** for other well-established terms e.g. problem solving, algorithmic thinking and critical thinking
- **The context of use** (academia versus policy documents)
- **Soundness** in national languages

CT as a competence

CT not only characterised by **skills**, but also by **attitudes** or dispositions

<table>
<thead>
<tr>
<th>Reference</th>
<th>CT dispositions / attitudes / attributes</th>
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| Barr, Harrison & Conery  (2011) | Confidence in dealing with complexity  
Persistence in working with difficult problems  
The ability to handle ambiguity  
The ability to deal with open-ended problems  
The ability to communicate and work with others to achieve a common goal or solution |
| Woollard (2016)          | Tinkering  
Creating  
Debugging  
Persevering  
Collaborating                                                                                     |
| Weintrop et al. (2015)   | Confidence in dealing with complexity  
Persistence in working with difficult problems  
Ability to deal with open-ended problems                                                               |

“We know from research that an important attitude for CT, which goes with this set of skills, is that students are able to **work with uncertainty in complex situations**, as well as having to be precise. Hence, there certainly are a number of attitudes that are also being developed while developing CT skills; for this reason, speaking of CT as a competence is reasonable” (Joke Voogt interview, 2016)
The Computational Thinker: Concepts & Approaches

Concepts
- Logic: predicting & analysing
- Algorithms: making steps & rules
- Decomposition: breaking down into parts
- Patterns: spotting & using similarities
- Abstraction: removing unnecessary detail
- Evaluation: making judgement

Approaches
- Tinkering: experimenting & playing
- Creating: designing & making
- Debugging: finding & fixing errors
- Persevering: keeping going
- Collaborating: working together

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Barefoot would like to acknowledge the work of Julia Briggs and the eLJM team at Somerset County Council for their contribution to this poster.
ACTIVITY - CRAZY CHARACTER

Barefoot activity designed for pupils aged 5-7
PISA 2021 Mathematics Framework
https://pisa.e-wd.org/#Formulate
Some of the key 21st Century skills

- critical thinking
- creativity
- research and inquiry
- self-direction, initiative and persistence
- information use
- systems thinking - CT is part
- communication
- reflection
PISA 2021: Computational Thinking

Mathematical Literacy in the 21st century includes mathematical reasoning and some aspects of computational thinking.

Computational Thinking involves processes that are very close to problem solving and collaborative problem solving assessed in PISA (p. 46)

Computational thinking skills include pattern recognition, decomposition, determining which (if any) computing tools could be employed in analysing or solving a problem, and defining algorithms as part of a detailed solution. By foregrounding the importance of computational thinking, the framework anticipates a reflection by participating countries on the role of computational thinking in mathematics curricula and pedagogy.
ICILS - IEA International Computer and Information Literacy Study 2018

1.4 Background to the study
1.5 Computer and information literacy
1.6 **Computational thinking**
1.7 Recent education policy developments related to CIL and CT
1.8 Research on the use of digital technologies in learning
1.9 Research questions
1.10 Participants and instruments

2 Computer and information literacy framework
2.1 Overview
2.2 Defining computer and information literacy
2.3 Revising the structure of the computer and information literacy construct
2.4 Structure of the ICILS 2018 computer and information literacy construct
2.5 Strands and aspects of computer and information literacy

3 **Computational thinking framework**
3.1 Overview
3.2 Defining computational thinking
3.3 Structure of the ICILS 2018 computational thinking construct
3.4 Strands and aspects of computational thinking

4 Contextual framework
4.1 Overview
Computational Thinking: Operational definition for K-12 education

Computational thinking (CT) is a problem-solving process that includes (but is not limited to) the following characteristics:

- **Formulating** problems in a way that enables us to use a computer and other tools to help solve them
- Logically **organizing** and **analyzing** data
- **Representing** data through abstractions such as models and simulations
- **Automating** solutions through algorithmic thinking (a series of steps)
- **Identifying, analyzing, and implementing** possible solutions with the goal of achieving the most efficient and effective combination of steps and resources
- **Generalizing** and **transferring** this problem solving process to a wide variety of problems

ISTE and CSTA, 2011
CT learning and teaching

Multiple pathways to CT should be used in compulsory education

• Over-reliance on coding might give pupils a wrong impression on what CT is

• Unplugged activities is regarded as an effective approach, involving problem solving and in the process dealing with fundamental concepts from CS

• Scalable Game Design builds on the motivational aspects foster a transfer of skills from game design to simulation

• Programming requires learning tools that can make programming accessible to young children in primary school

• Integration!

• Bebras – Challenge on Informatics and CT
What is Bebras?
**Challenge in Informatics**

- **BEBRAS** (Beaver) – International Challenge on Informatics and Computational Thinking
- Established in 2004

**Shift:** algorithmic thinking to computational thinking
informatics for informatics to informatics for all

**Goals**
- to **develop** Computational Thinking
- to **stimulate** pupils’ interest in informatics and information technology
- to **encourage** pupils to *think* deeper while using computers and information technologies
- to **inseminate** concepts of informatics
**What is Bebras**

Bebras is an international initiative aiming to promote informatics (Computer Science, or Computing) and computational thinking among school students at all ages. Participants are usually supervised by teachers who may integrate the Bebras challenge in their teaching activities. The challenge is performed at schools using computers or mobile devices.

**What does Computational Thinking involve?**

Computational thinking involves using a set of problem-solving skills and techniques that software engineers use to write programs and apps. The Bebras challenge promotes problem-solving skills and informatics concepts including the ability to break down complex tasks into simpler components, algorithm design, pattern recognition, pattern generalization and abstraction. More about computational thinking.

**Dates**

The second week of November is declared as World-Wide BEBRAS week for solving tasks. Some countries extended it to two weeks. Many countries run all-year-round Bebras activities like participants awarding events, second round of the challenge, summer camps, teacher workshops, collecting statistics and writing research papers.

Read more...
Berbas története


Workshop-ek

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2018.
2017.
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2018 November – 2019 April
Bebras tasks

- Attract students and drive them to learn and explore as well to develop skills in the particular area
- Require deep-thinking skills in the informatics field
- Clearly related to fundamental informatics concepts

Dagienė, V., Stupurienė, G. Bebras – a Sustainable Community Building Model for the Concept Based Learning of Informatics and Computational Thinking. (2016)
ABSTRACTION – WALNUT ANIMAL

Question:
Which of the following figures can be bent back to make the figure of the dog again?
Beaver Ana has a treasure map. She knows that the treasure position is at (7|7).

Ana knows that the well is at (7|5) and the fireplace is at (3|3). But she forgot how to read the map the right way round.

Where is the treasure? Drag and drop the treasure to the map.
Clara likes colorful bouquets of flowers and visits a flower shop. In there are the following types of flowers: gladiolus, lily, tulip, rose.

Every flower is available in the colors:

Clara wants a bouquet with six flowers satisfying the following conditions:

1. each of the colors yellow, white and blue should occur exactly twice,
2. flowers of the same type should not have the same color,
3. every type of flower should only occur at most twice.

Which of the following bouquets satisfies all the conditions 1), 2) and 3)?
EVALUATION - BRACELET

Emily has broken her favourite bracelet. The broken bracelet now looks like this:

Question:
Which of the following four bracelets shows what the bracelet looked like when it was whole?

A  B  C  D

To solve this problem it is necessary to evaluate the four options and consider which fits the original bracelet.
Beaver has developed a very simple modeling language. It consists only of two kinds of objects and two possible operations. The operation \( \text{add}(A, B) \) means: Put \( A \) and \( B \) side by side and glue \( B \) to the right side of \( A \). The operation \( \text{turn}(A) \) means: turn \( A \) clockwise around 90 degrees.

Which operation sequences would generate this thing?

A
A = \text{add}(cylinder, cylinder)
B = \text{turn}(A)
C = \text{turn}(B)
D = \text{add}(C, cube)

B
A = \text{add}(cylinder, cylinder)
B = \text{add}(A, cube)
C = \text{turn}(B)
D = \text{add}(C, A)

C
A = \text{add}(cube, cube)
B = \text{add}(A, cylinder)
C = \text{turn}(B)
D = \text{add}(C, cylinder)

D
A = \text{add}(cube, cylinder)
B = \text{add}(A, cylinder)
C = \text{turn}(B)
D = \text{add}(C, cylinder)
E = \text{add}(D, cylinder)
Generalisation is associated with identifying patterns, similarities and connections, and exploiting those features. It is a way of quickly solving new problems based on previous solutions to problems, and building on prior experience.
You can think of a computer as a device that reads *input* and writes *output*. How does a computer “know” what to do? The answer is that humans tell it what to do beforehand!
Task cards BEBRAS
Abstraction: Identifying and extracting relevant information to define main ideas. Abstraction is simplifying things by removing unnecessary detail.

Logics: The study of reasoning; predicting and analysing. Helping us to try to make sense of things - to establish and check facts.

Data Analysis: The process of gathering appropriate information. Making sense of data by finding patterns or developing insights.

Decomposition: Breaking down data, processes, or problems into smaller, manageable parts.

Algorithms: Creating an ordered series of steps for solving problems or for doing a task. An algorithm is a sequence of instructions, or set of rules, for performing a task.

Simulation: Developing a model to imitate real-world processes. Executing sequences of commands and programs.

Systematic Evaluation: Making judgements, in an objective and systematic way whenever possible. Evaluation is something we do every day; we make judgements about what to do and what we think based on a range of factors.

Generalization: Creating models, rules, principles, or theories of observed patterns to test predicted outcomes.
BEBRAS card task

Solve the task in the small group, watch the solving process and discuss about it after.
COLOURFUL TOWER

A little beaver girl put rings on the top of each other in this sequence:
1) Red
2) Green
3) Yellow
Repeats till the last correctly coloured ring.

How many rings will the tower have?

BEAVERS HOUSE

Beaver house windows are marked by row & column numbers, e.g. windows on the door's right: [1, 3] and [2, 3]. Beaver replaced windows: [1, 2]; [1, 6]; [2, 2]; [2, 5] last year.

This year he wants to replace other windows, but only those, which have 4 “neighbours”: to the left, right, above & below.

How many windows Beaver is going to replace this year?

This game is one of the simplest examples of algorithms. In everyday life we do many kinds of actions by following sets of rules. Using rules makes doing many routine tasks easier and faster. If we can write rules exactly, describe and express them using commands, we can control a robot to execute these commands.
Little beaver wants to present a necklace to his girlfriend beaver. He knows she wants a specific one:

1) Sorb apples have to be between pine needles and
2) Amount of apple seeds have to be equal to the amount of pine needles.

Which necklace will little beaver girl like?
Robot is collecting interesting stones by repeating the commands:
- **IF** there is one stone in the square, then move to the next square,
- **IF NOT** - take one stone and move forward the same number of squares as there are stones left on the square.

How many stones will be gathered by the robot?

An important thing when you program is to write down the commands which do things you want to do. The selection command, presented here, is quite complex. Its condition is a number of little stones. If there is more than one stone, then two commands are implemented: take one little stone and move forward a number of squares.
Beaver created two robots: cat and mouse. Both of them can move from one square to another following the arrows. Cat wants to hunt the mouse.

- Cat starts first.
- Moves are made in alternately (cat, mouse, cat, mouse, etc.).
- The robots move in the direction indicated by the arrows as many squares as there are arrows (e.g. one square if there is one arrow, two squares if two arrows and etc.).
- When a robot is moving, it ignores the arrows on the squares.
- Mouse is eaten, when the cat is on the same square as the mouse.

A playground is a simple program; start and finish is specified and there are rules that determine actions. Arrows in squares clearly and non-ambiguously determine where to go next. It is important that our mechanisms would understand these arrows. Cat and mouse are the mechanisms of this problem which can move according to the arrows.
A little Beaver Lina uses an exciting method to create pictures. She cuts out a stencil of the castle in a card board panel. Then she places colourful bricks in it.

Lina created this picture:

In how many different ways is it possible to create this picture?

This problem is related to combinatorics. Combinatorics is a branch of mathematics that deals with combinations of objects belonging to a finite set in accordance with certain constraints. The aim is to find the number of possible ways to achieve these combinations. The method used in this problem is called brute force and is based on the consideration of all possible solutions.
Integration – Phenomenon based learning

• The publishing house „Baltos Lankos“ (Lithuania) has been publishing standards-based integrated curriculum textbooks Rainbow for primary education since 2010

• The primary school curriculum (grades 1-4) is divided into 36 general themes and 130 more specific topics with 9 books for each school year

• The full set of the textbook includes a workbook and an online platform, audio and video records as well as other learning materials

• Starting from 2019, Computational Thinking is part of this integrated textbook!
Valentina Dagienė

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Robot and the Tower

Robot should reach the Tower by walking from square to square.

The programmer has made a program out of movement direction commands marked by arrows:

→ ↓ → → ↓ → → ↑ ↑ ↑ ← ↑ ↓ → →

However, he made a mistake. The program can be corrected by rotating one of the arrows. Fix it.
Thank you

valentina.dagiene@mif.vu.lt