Vilnius University

Computational Thinking – Bebras Style

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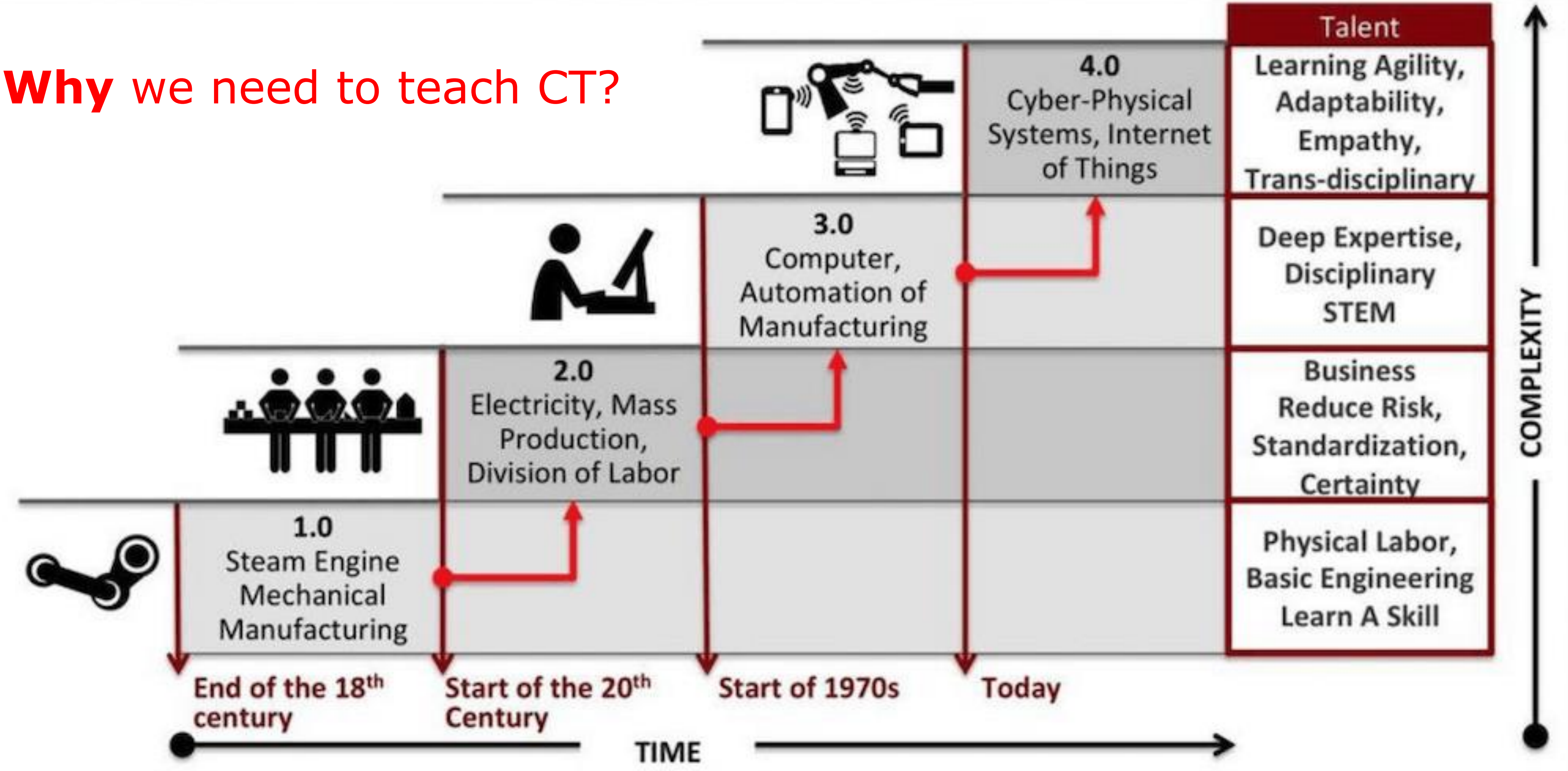
My talk about

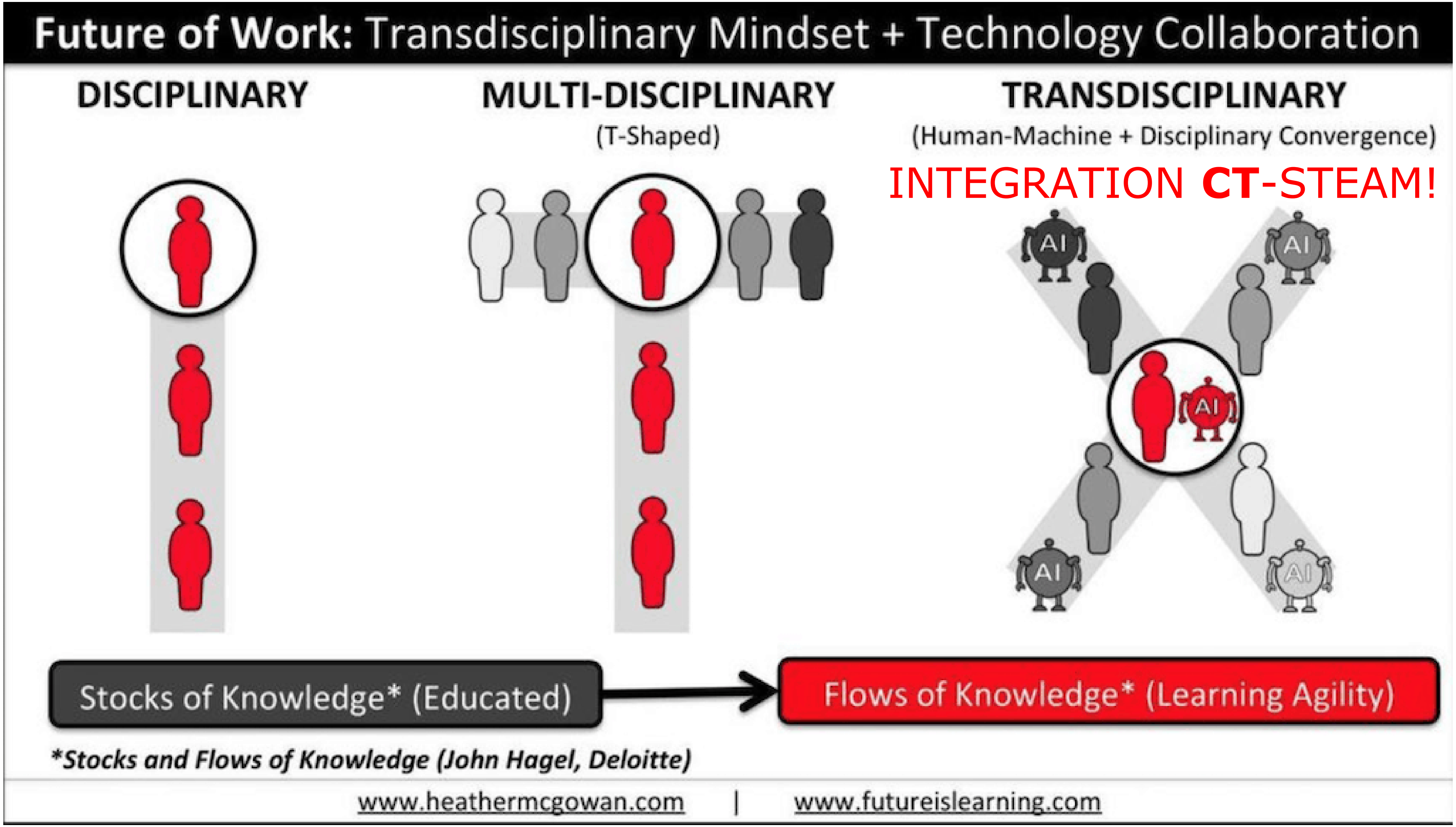
- What is Computational Thinking
- Components of Computational Thinking
- UK model: Concepts and Approaches
- Future PISA 2021 and Computational Thinking
- What is Bebras?
- The Bebras tasks – many examples
- The Bebras game cards

Future of Work: 4th Industrial Revolution (World Economic Forum)

Why we need to teach CT?



www.heathermcgowan.com | www.futureislearning.com



Future of Work: Transdisciplinary Mindset + Technology Collaboration
DISCIPLINARY
MULTI-DISCIPLINARY
(T-Shaped)
TRANSDISCIPLINARY
(Human-Machine + Disciplinary Convergence)
INTEGRATION CT-STEAM!
AI
Stocks of Knowledge* (Educated)
Flows of Knowledge* (Learning Agility)
*Stocks and Flows of Knowledge (John Hagel, Deloitte)
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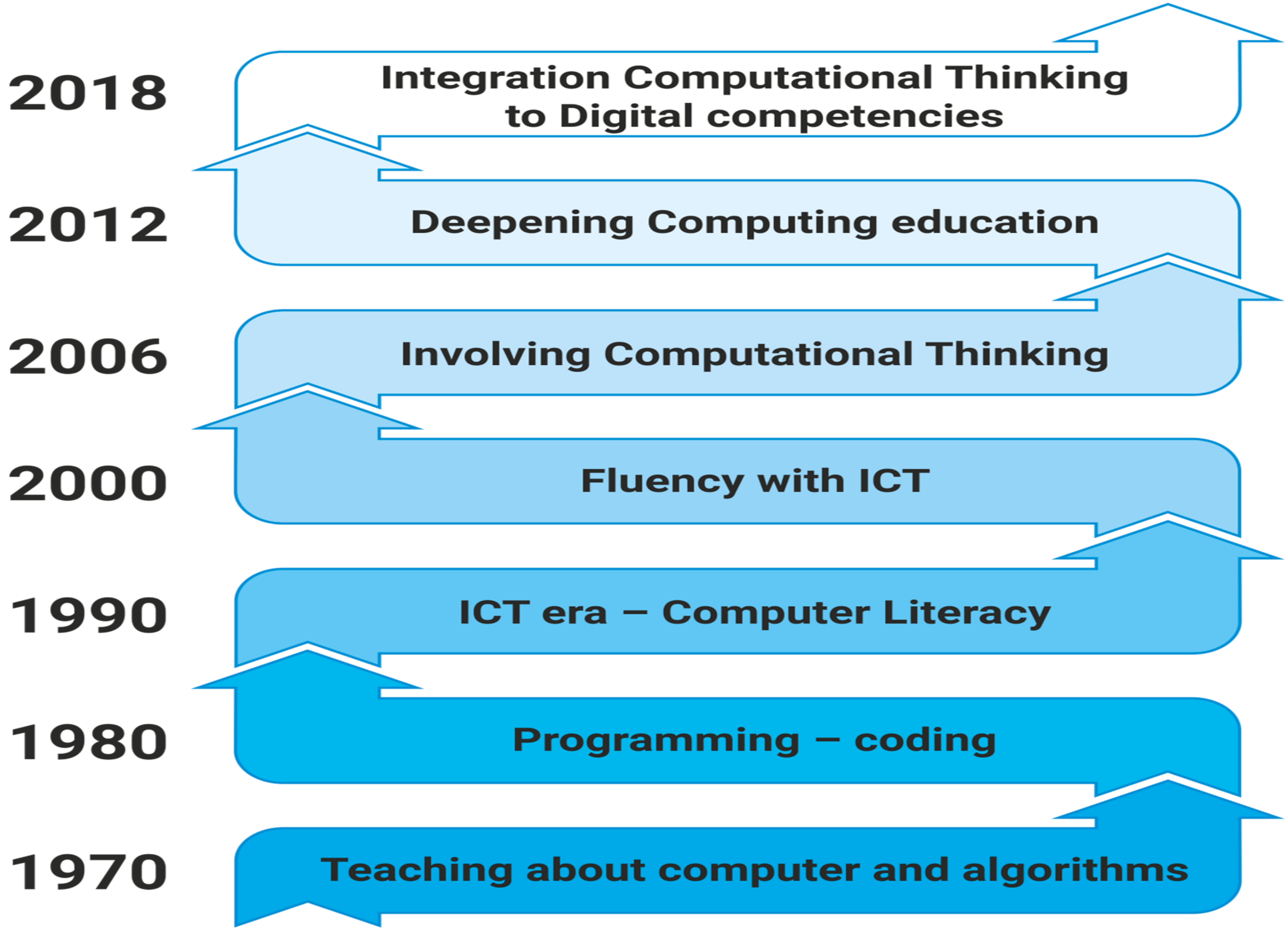
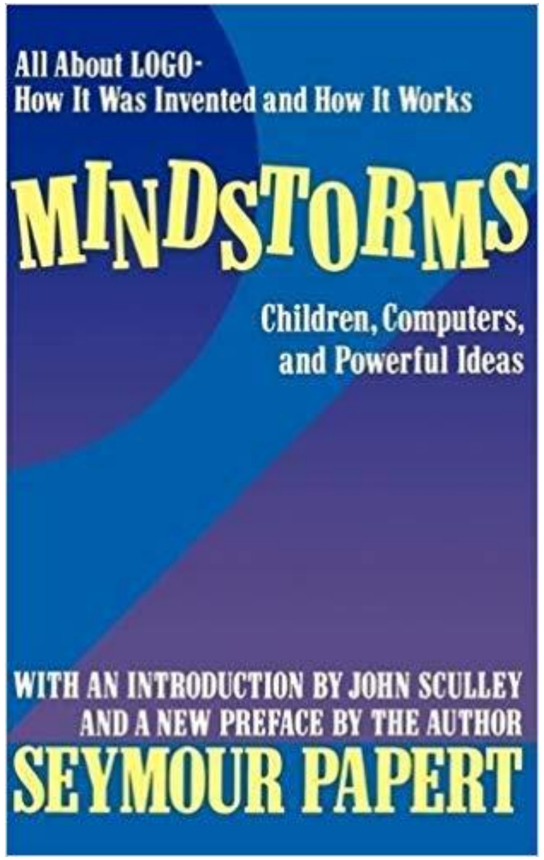
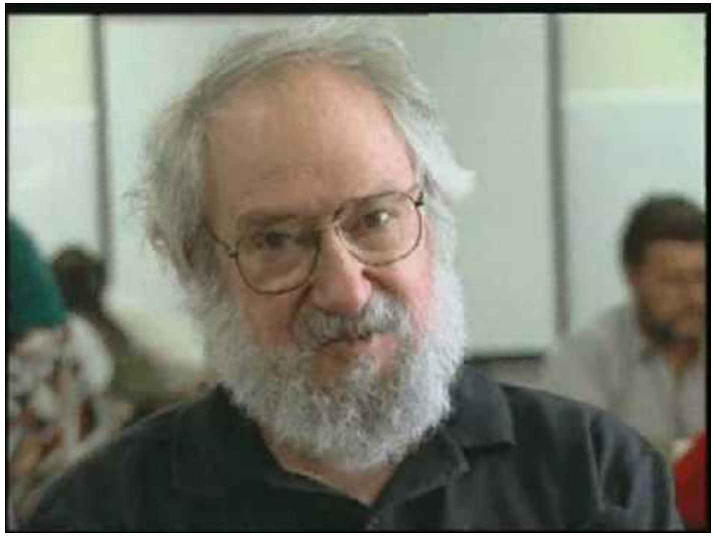
Computing education – shifts in approach



Computational Thinking

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






2006 Hanoi

Computational Thinking

Popularized by Jeanette M. Wing in 2006

Jeanette M. Wing
Carnegie Mellon University

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

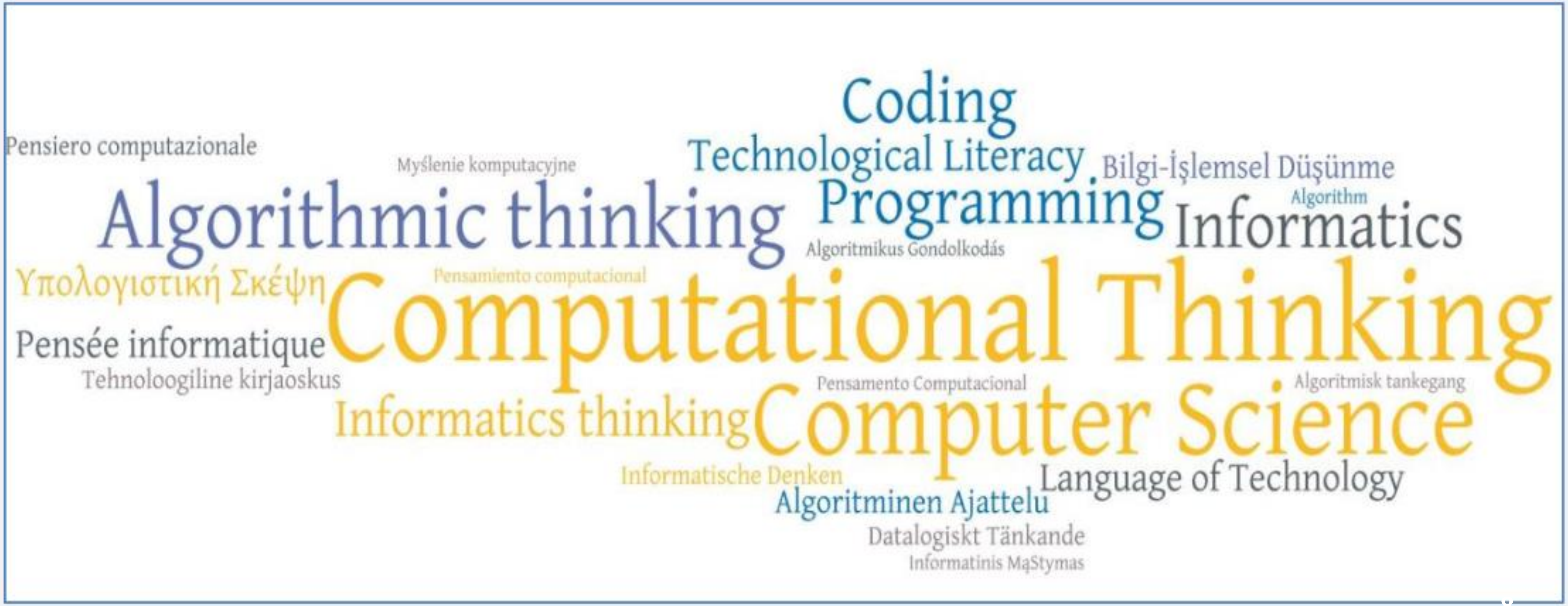
„an universally applicable attitude and skill set everyone, not just computer scientist, would be eager to learn and use"

J.M.Wing. Computational thinking. Communications of the ACM, 2006.

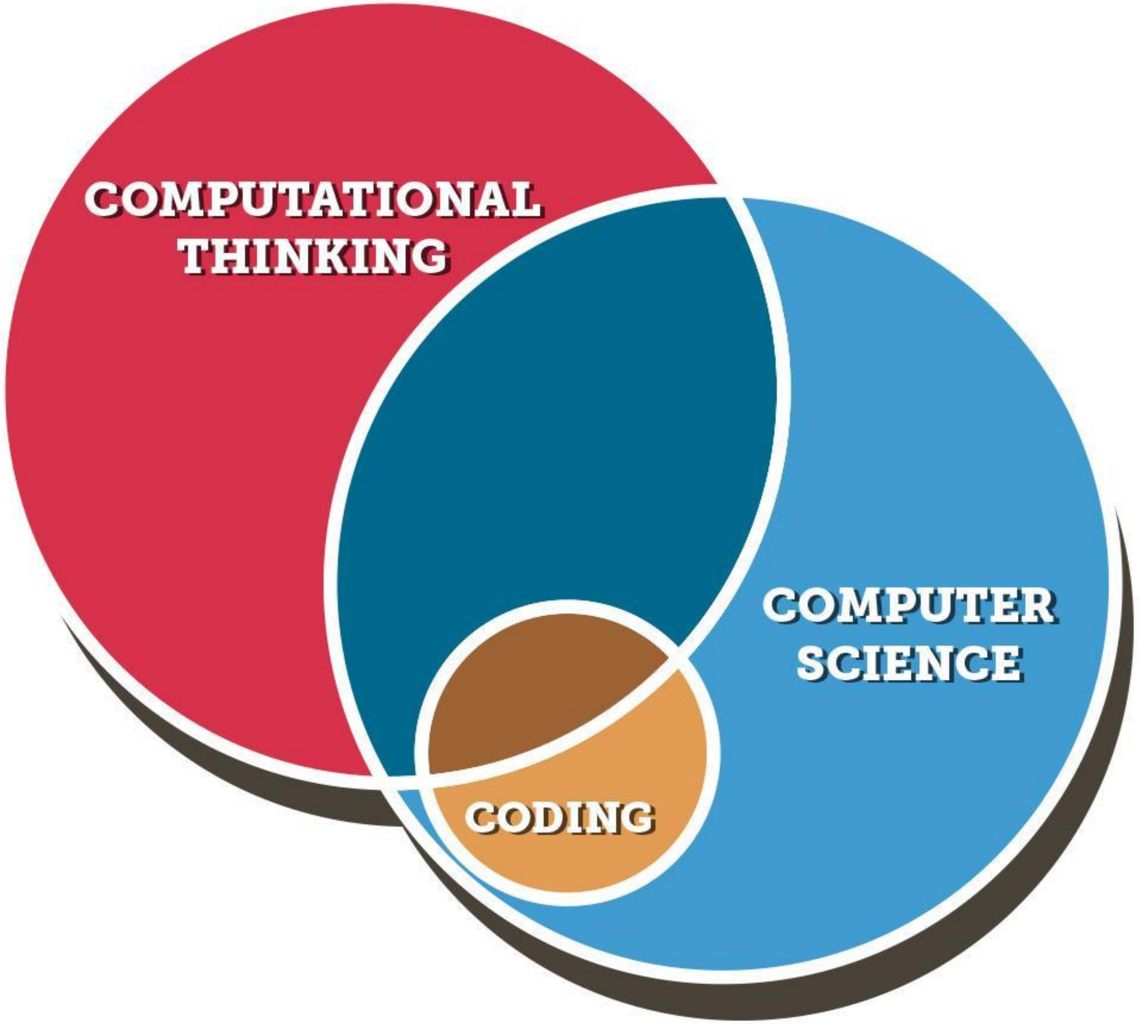
„Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent"

J. Cuny, L. Snyder, and J. M. Wing. Demystifying Computational Thinking for Non-Computer Scientists, 2010

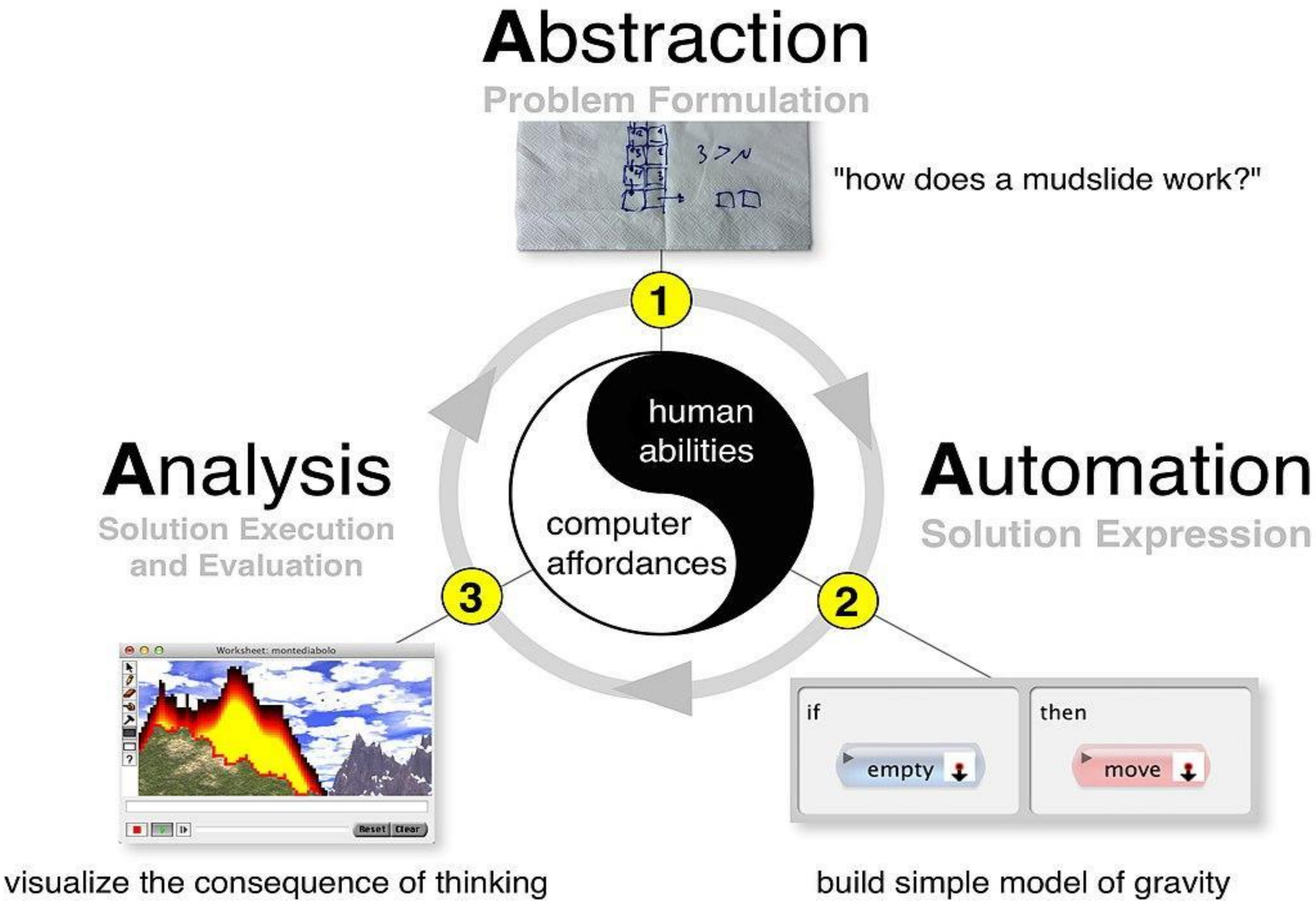
CT – Terminology



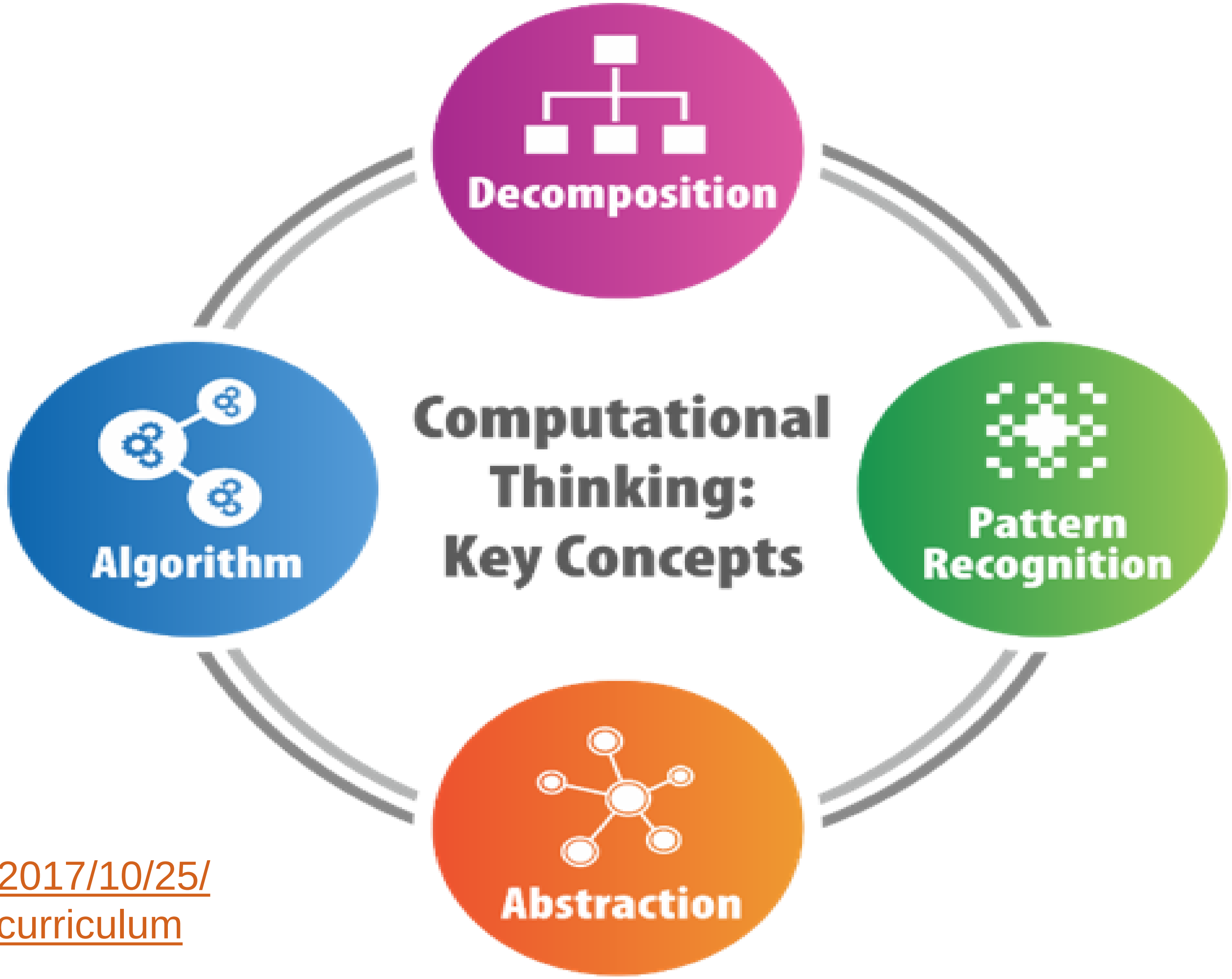
CT for Computational World



http://digitalpromise.org/wp-content/uploads/2017/12/dp-comp-thinking-v1r5.pdf

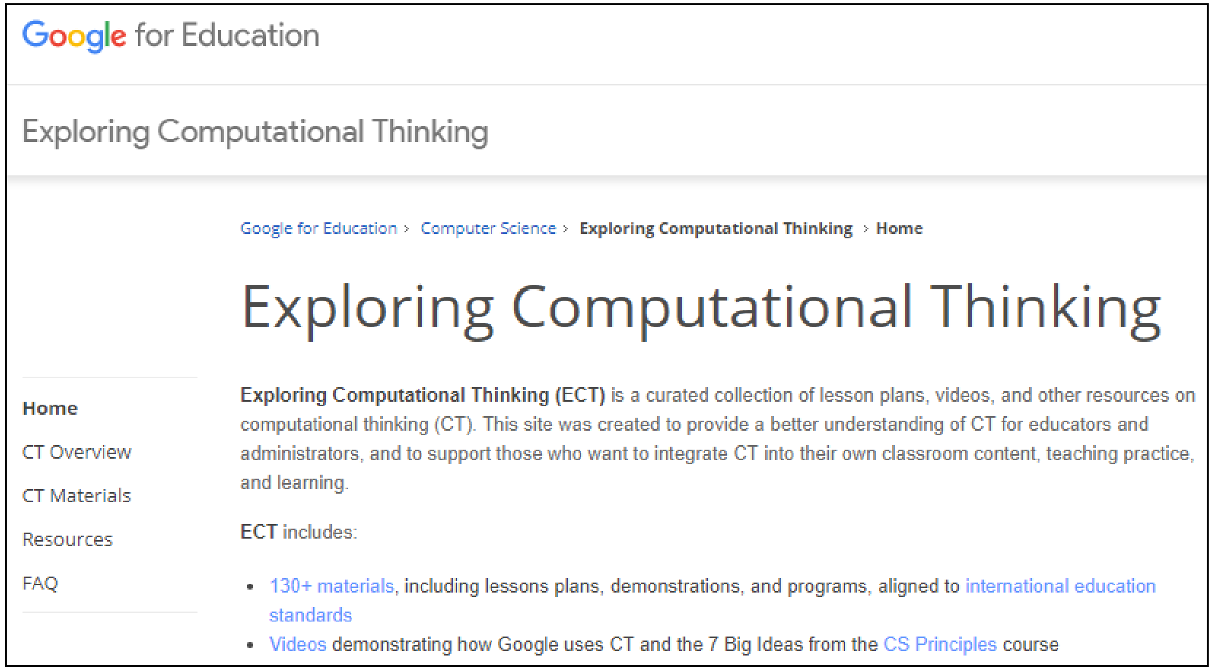

Abstraction
Problem Formulation
"how does a mudslide work?"
1
human
abilities
computer
affordances
Analysis
Solution Execution
and Evaluation
Automation
Solution Expression
3
2
Worksheet: montediabolo
Reset
Clear
if
then
empty
move
visualize the consequence of thinking
build simple model of gravity

CT Key Components



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)

F. Kalelioglu, Y. Gulbahar, V. Kukul. A Framework for Computational Thinking Based on a Systematic Research Review. *Baltic J. Modern Computing*, Vol. 4 (2016), No. 3, 583-596

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, programing, 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


JRC SCIENCE FOR POLICY REPORT

Developing Computational Thinking in Compulsory Education

Implications for policy and practice

Computational Thinking Study

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:

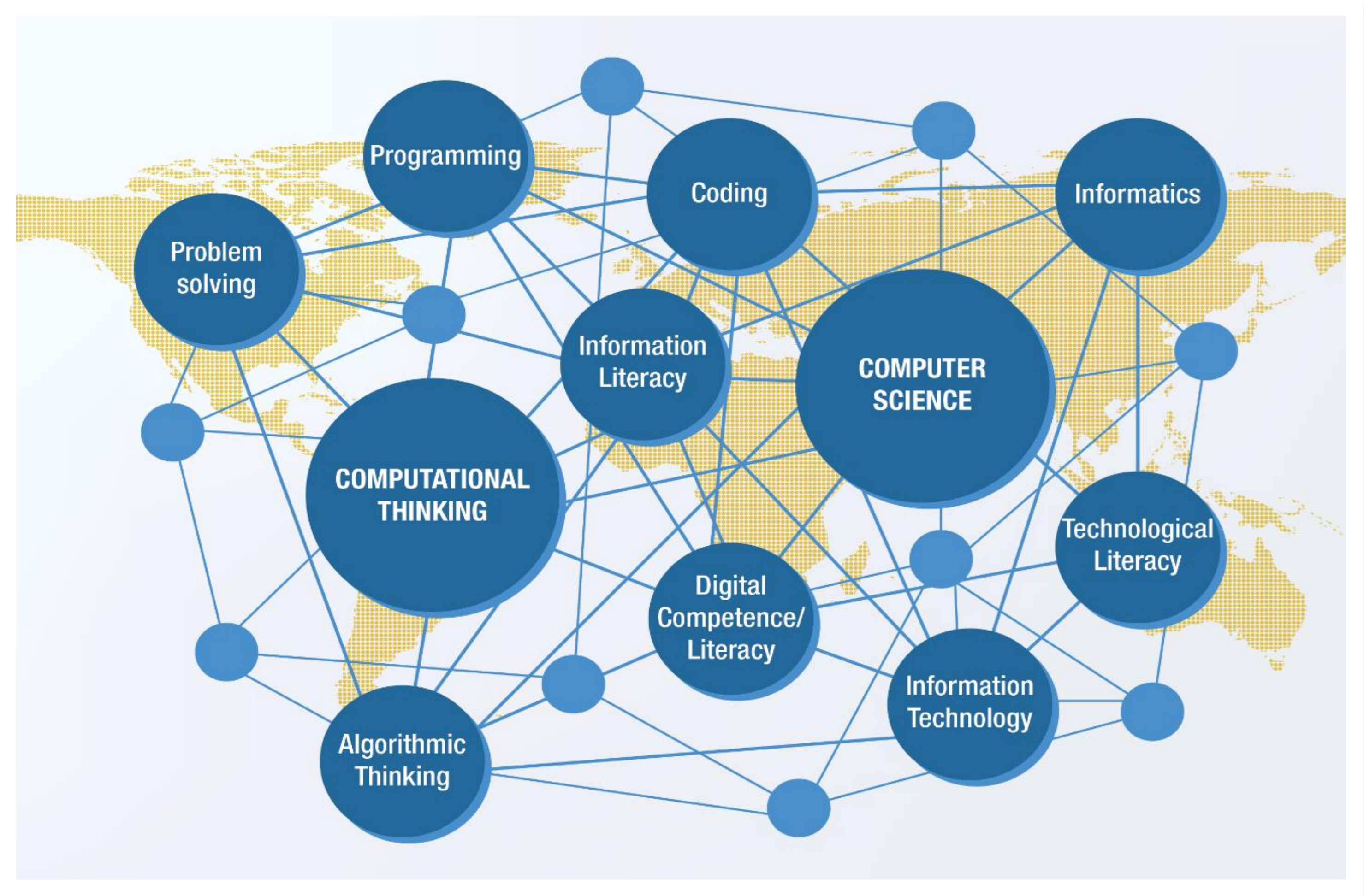
> How can we define CT as a key 21st century competence for schoolchildren?

Related Publications

- A review of fuel performance modelling
- Computational models for the assessment of manufactured nanomaterials: development of model reporting standards and mapping of the model landscape
- The future of in silico chemical safety ... and beyond
- Unlocking the potential of in silico chemical safety assessment: A report on a cross-sector symposium on current opportunities and future challenges
- Advances in the Prediction of Gastrointestinal Absorption:

https://ec.europa.eu/jrc/en/computational-thinking

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

https://publications.jrc.ec.europa.eu/repository/bitstream/JRC104188/jrc104188_computhinkreport.pdf

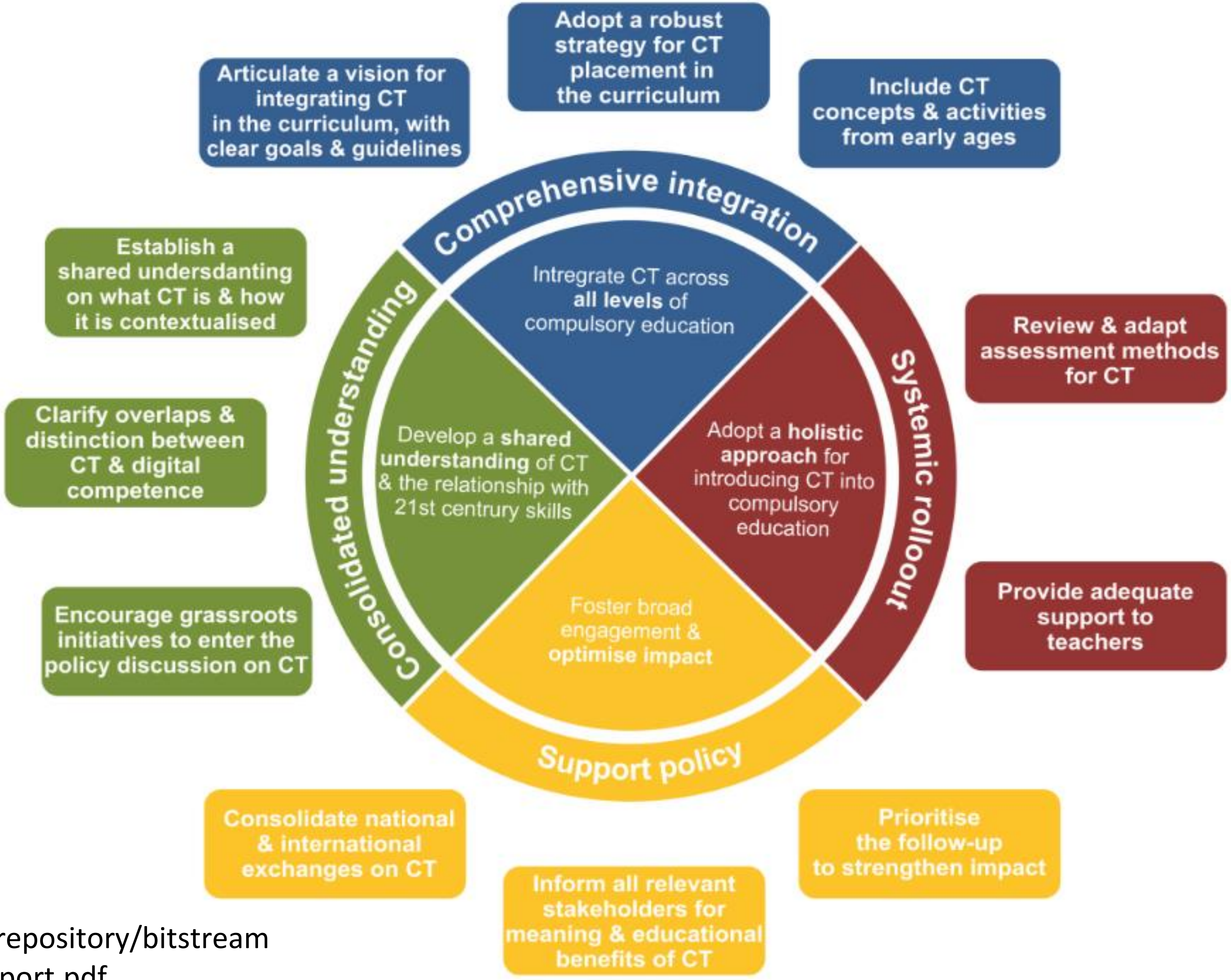
CT as a competence

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

Reference	CT dispositions / attitudes / attributes
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 dea Persistence in wo Ability to deal wit

*"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)

CT Model



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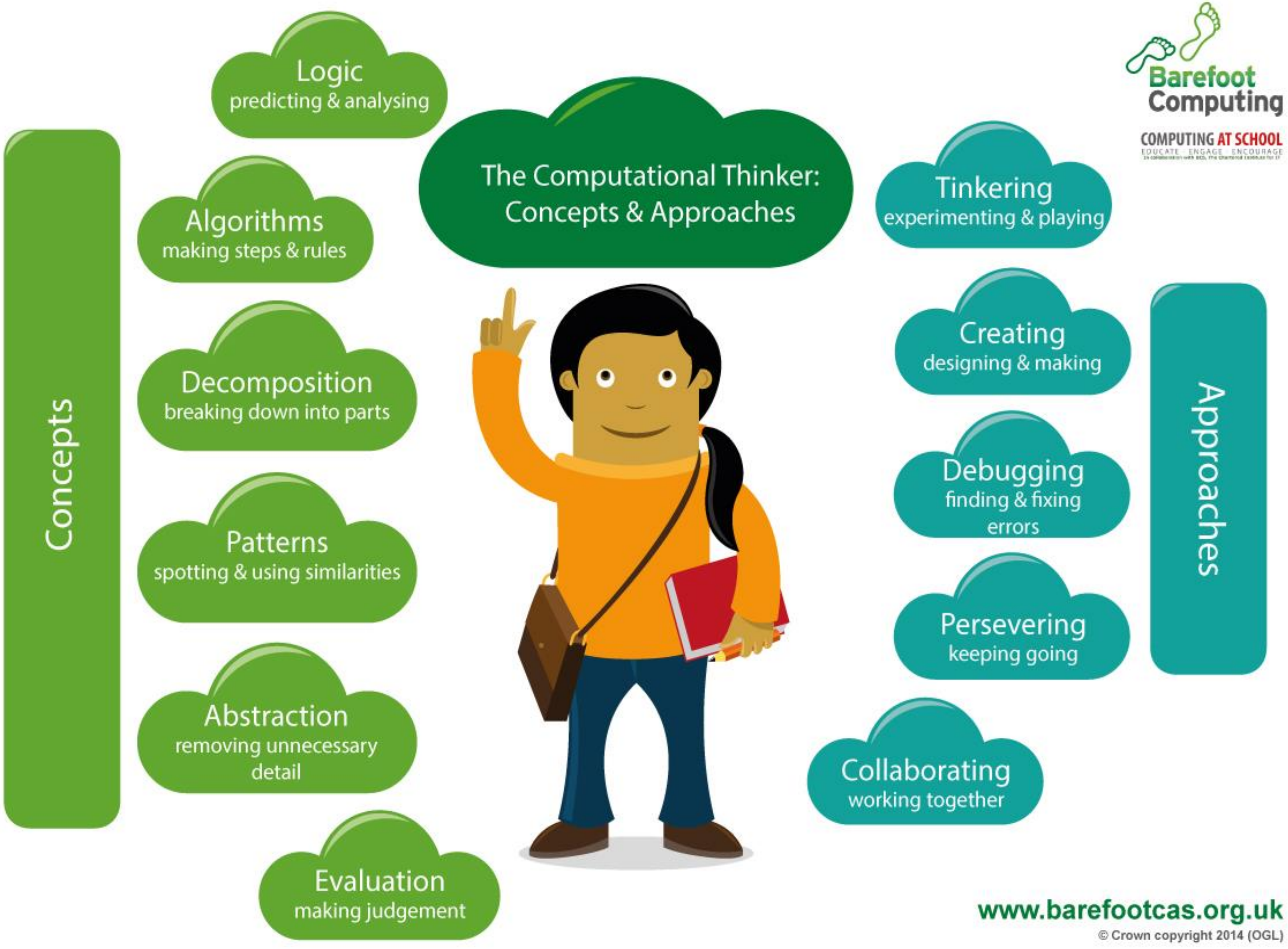
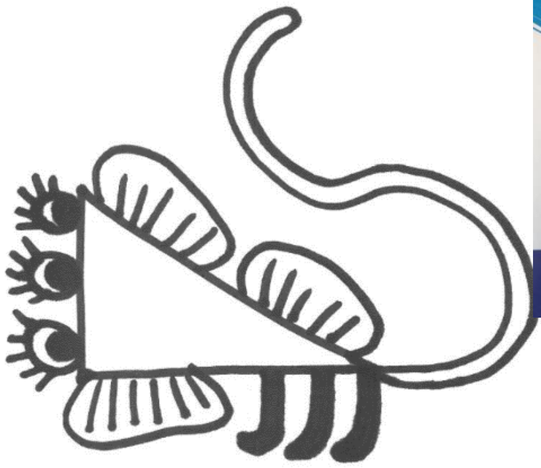
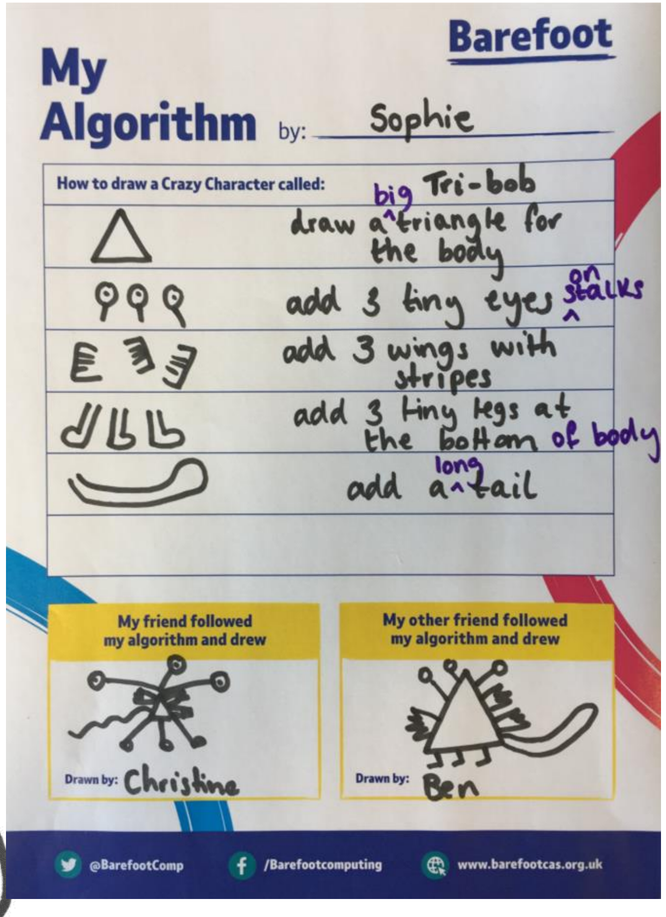


Barefoot would like to acknowledge the work of Julia Briggs and the eLIM team at Somerset County Council for their contribution to this poster.

ACTIVITY - CRAZY CHARACTER

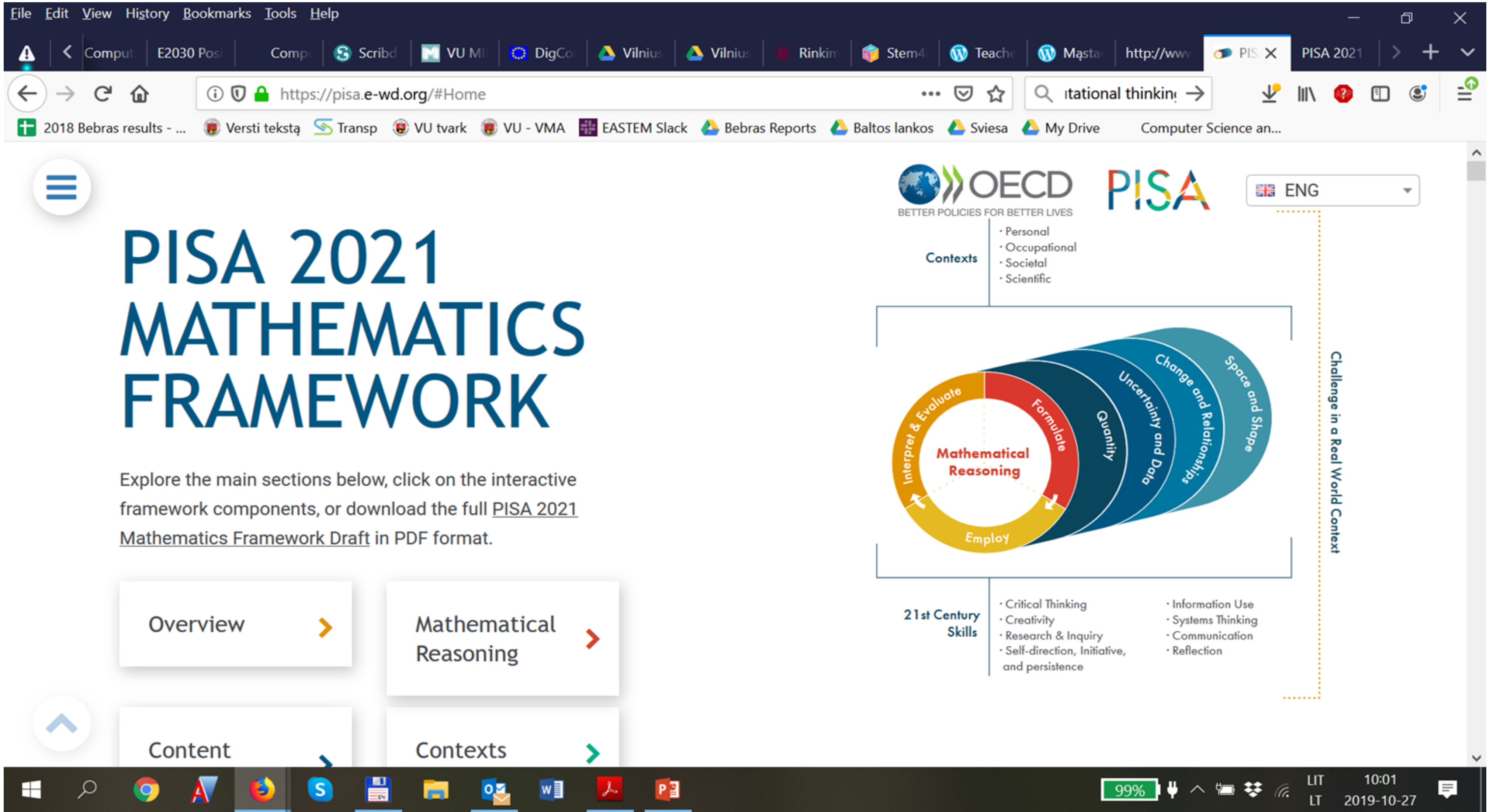




Barefoot activity designed for pupils aged 5-7

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 21stcentury includes mathematical reasoning and some aspects of computational thinking

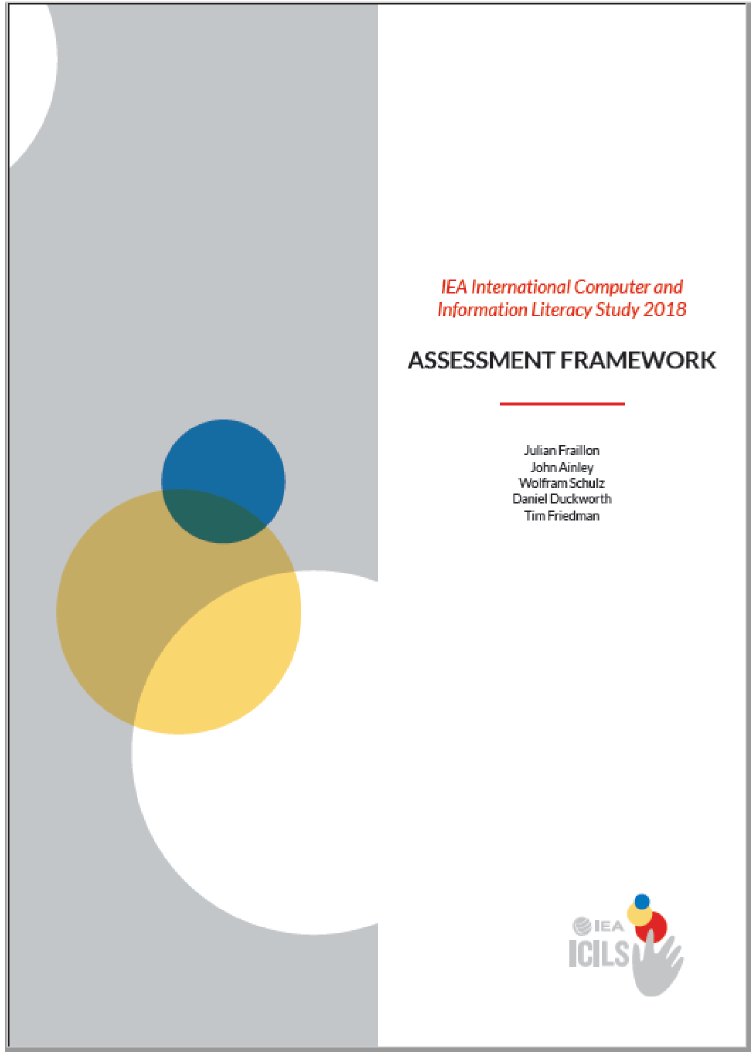
Computational Thinking involves processes that are very close to problem solving and collaborative problem solving assessed in PISA (p. 46)

https://pisa.e-wd.org/files/PISA%202021%20Mathematics%20Framework%20Draft.pdf

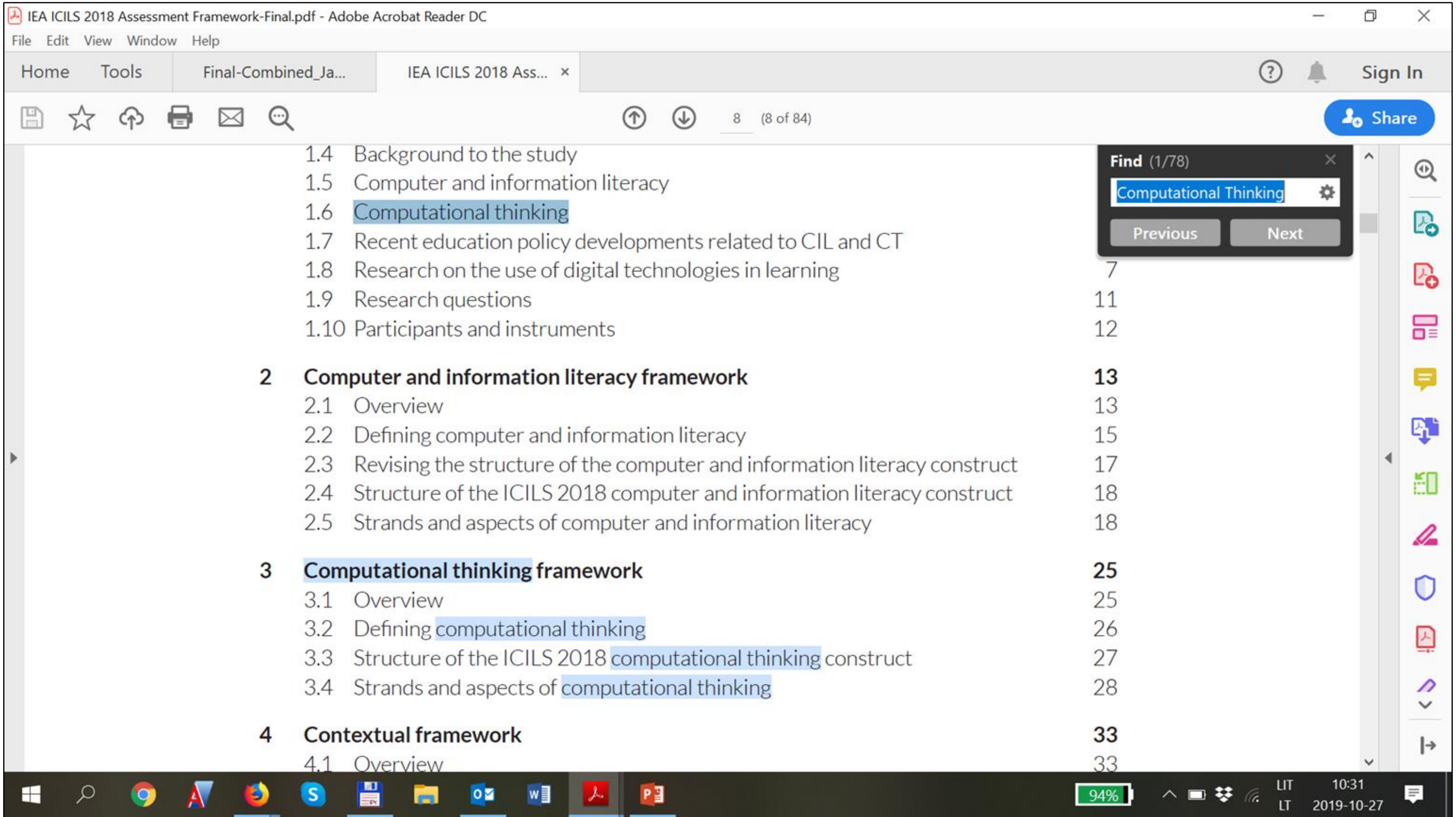
PISA 2021: Computational Thinking

- 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



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
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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?

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

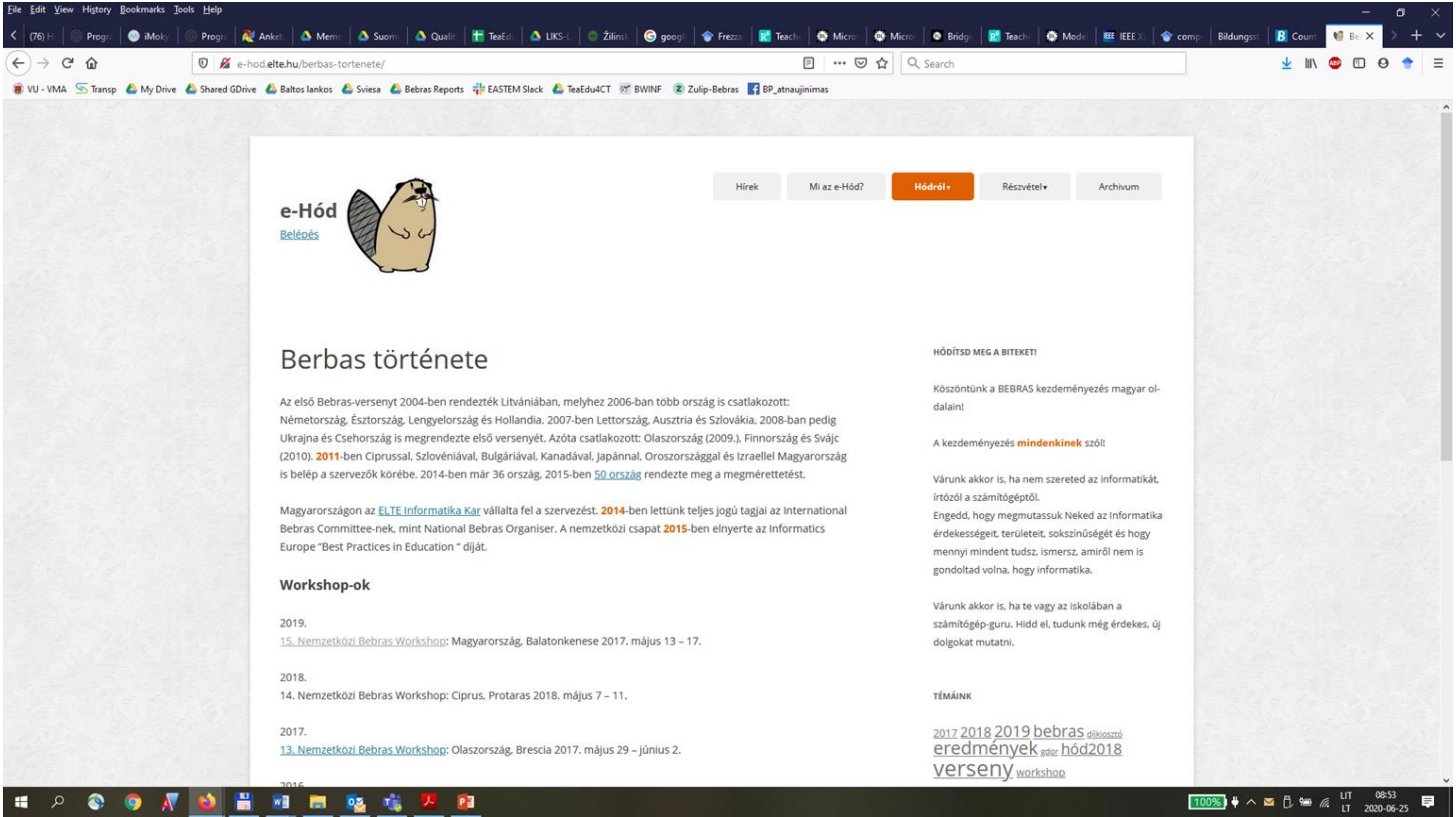
Goals

- 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

International website

www.bebras.org

http://e-hod.elte.hu



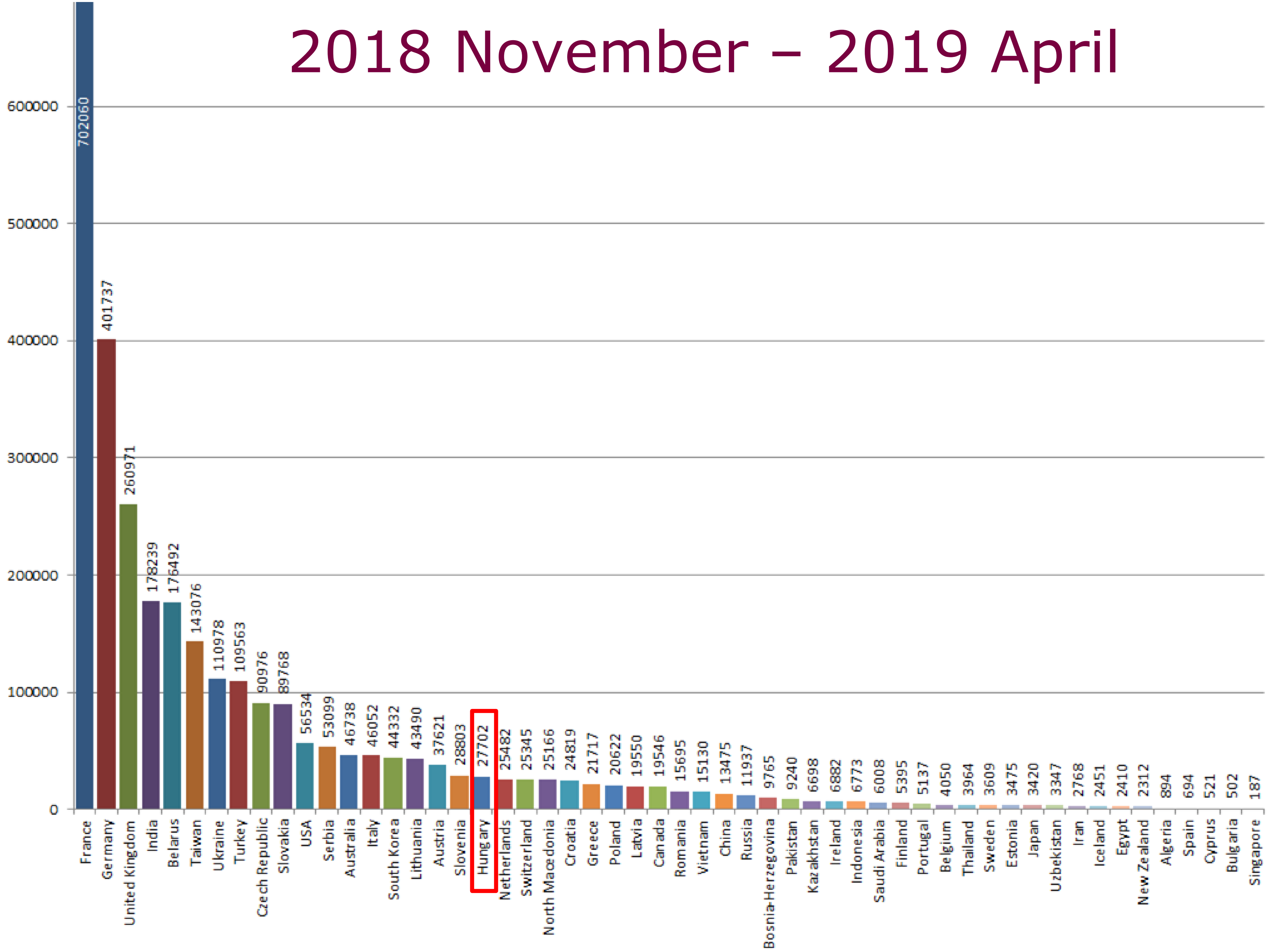

BEBRAS
Australia
Austria
Australia
Azerbaijan
Belarus
Belgium
Bulgaria
Dabar
Informatičar
Bosnia & Hercegovina
Canada
China
Croatia
Cyprus
BOBŘÍK
informatiky
Czechia
BEBRAS EGYPT
Egypt
Estonia
Finland
France
Germany
Hungary
Iceland
India
Indonesia
Iran
Ireland
Israel
Italy
Japan
Jordan
Latvia


b·e·b·r·a·s
Lithuania
North Macedonia
Malaysia
Beverwedstrijd
Netherlands
New Zealand
Norway
INTERNATIONAL BEBRAS INFORMATICS CONTEST
PAKISTAN
Pakistan
Poland
Portugal
Romania
БОБЁР
Russia
Serbia
Singapore
Slovakia
Slovenia
South Africa
South Korea
Spain
Sweden
Switzerland
Taiwan
Thailand
Turkey
United Kingdom
USA
Бобер
Ukraine
Vietnam

2018 November – 2019 April

Country	Total	Country	Total	Country	Total
Algeria	796	Iceland	1 357	Romania	14 976
Australia	43 163	Indonesia	5 065	Serbia	50 168
Austria	32 675	India	137 081	Singapore	1 352
Belarus	150 237	Iran	4 161	Slovakia	77 928
Belgium	4 400	Ireland	6 851	Slovenia	33 590
Bosn & Herc	9 732	Italy	51 297	S. Africa	21 035
Bulgaria	514	Japan	5 128	S. Korea	25 455
Canada	18 874	Kazakhstan	4 671	Spain	965
China	104 573	Latvia	17 574	Sweden	5 499
Croatia	22 887	Lithuania	44 136	Switzerland	21 313
Czechia	79 988	Malaysia	6 815	Taiwan	118 332
Estonia	3 458	Netherlands	18 852	Tunisia	5 708
Finland	5 613	N. Zealand	2 745	Turkey	68 484
France	682 053	N. Macedonia	25 372	Ukraine	117 885
Germany	373 406	Pakistan	8 754	UK	201 911
Greece	13 905	Philippines	2 236	USA	46 699
Hong Kong	4 659	Poland	22 540	Vietnam	12 957
Hungary	**27 702**	Russia	12 909	Thailand	4 132

2018 November – 2019 April



Bebras tasks

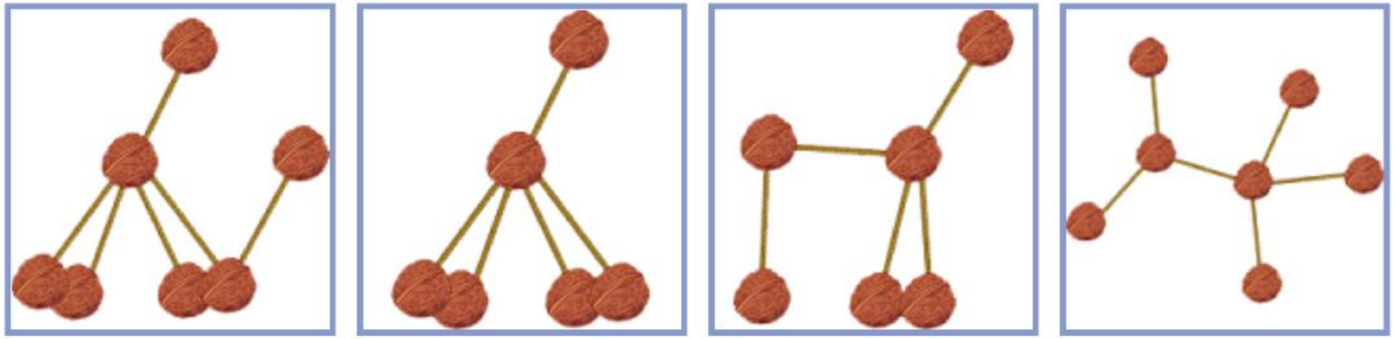
- Attract students and drive them to learn and explore as well to develop skills in the particular area
- Require deep-thinking skills in the informatics field
- Clearly related to fundamental informatics concepts

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

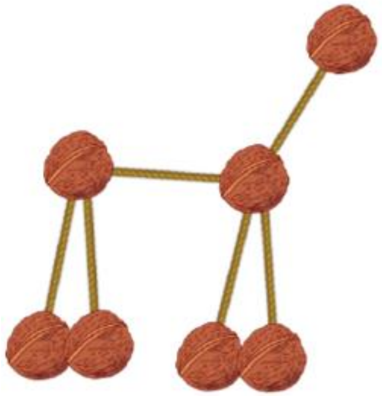
Abstraction – Walnut animal

Question:

Which of the following figures can be bent back to make the figure of the dog again?



Dog



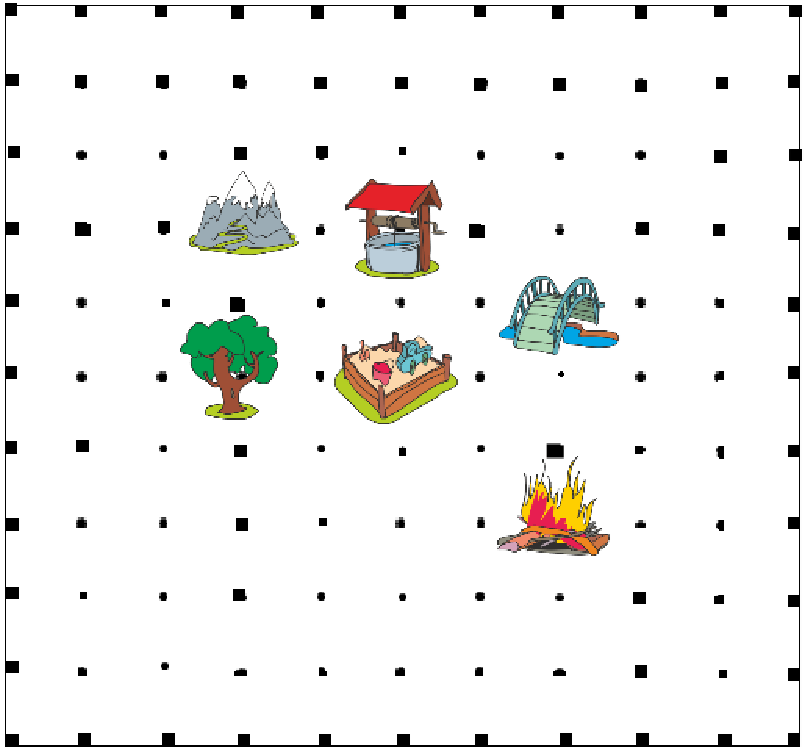
Representation - Treasure Map

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.



Logics - Clara likes flowers

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)?

A 

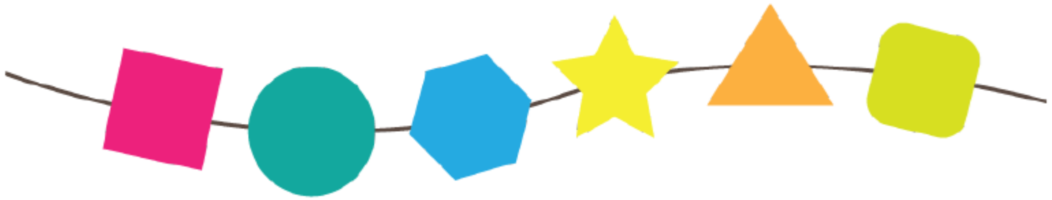
B 

C 

D 

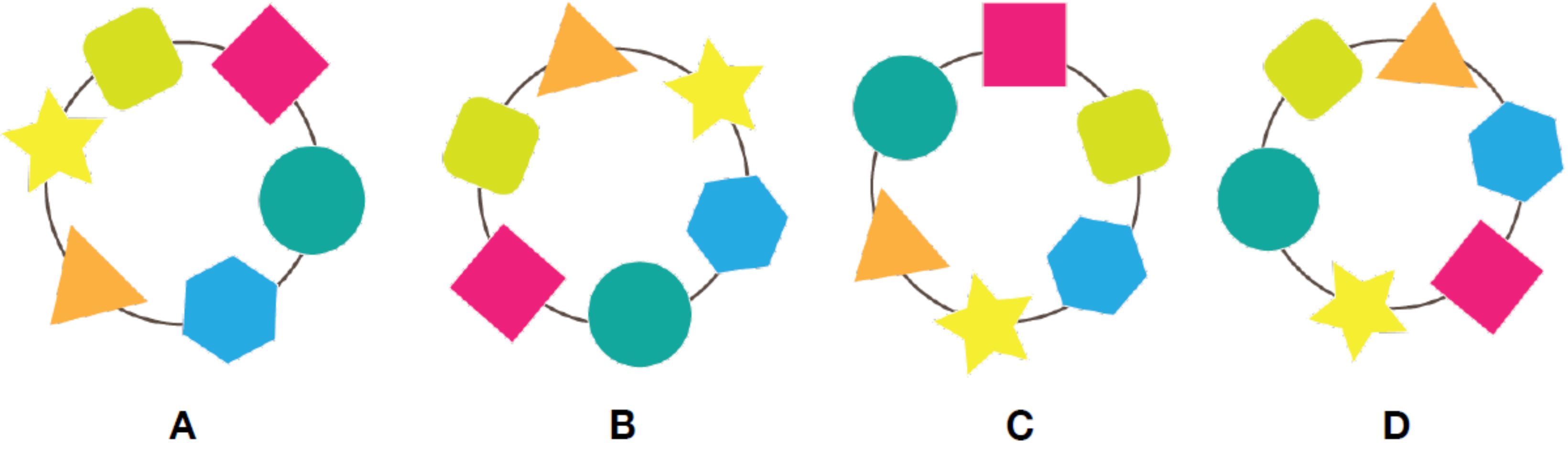
Evaluation - Bracelet

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



Question:

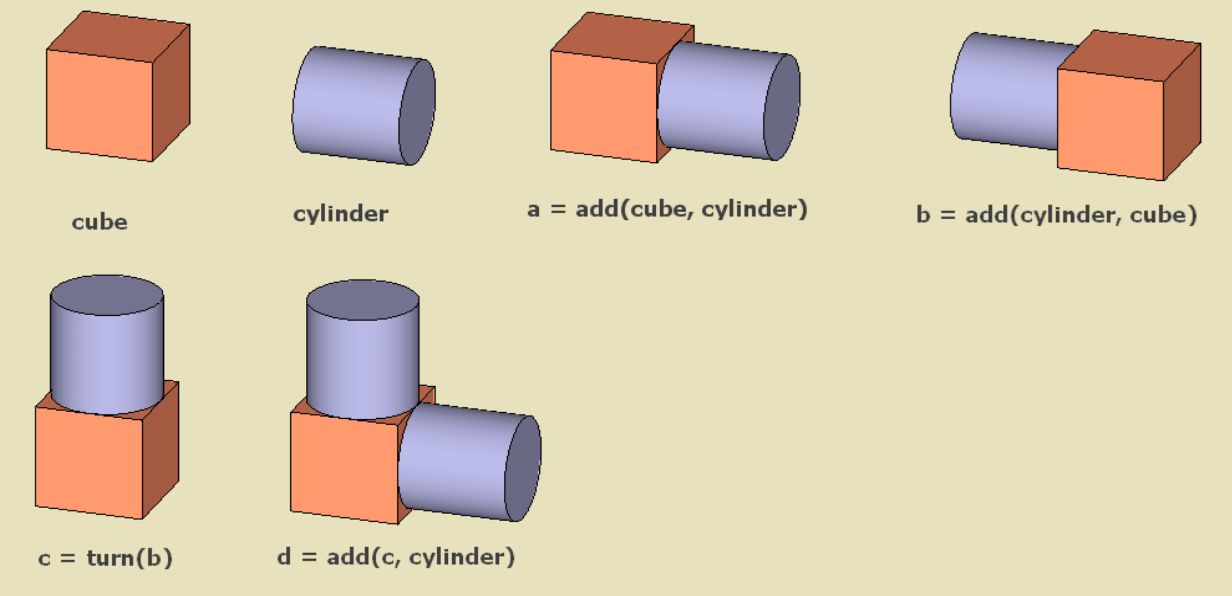
Which of the following four bracelets shows what the bracelet looked like when it was whole?



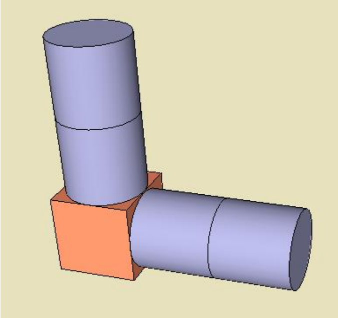
To solve this problem it is necessary to evaluate the four options and consider which fits the original bracelet.

AUTOMATION - CONSTRUCTIVE BEAVER

Beaver has developed a very simple modeling language. It consists only of two kinds of objects and two possible operations



Which operation sequences would generate this thing?



The operation add(A, B) means: Put A and B side by side and glue B to the right side of A. The operation turn(A) means: turn A clockwise around 90 degrees.

A

A = add(cylinder, cylinder)
B = turn(A)
C = turn(B)
D = add(C, cube)

B

A = add(cylinder, cylinder)
B = add(A, cube)
C = turn(B)
D = add(C, A)

C

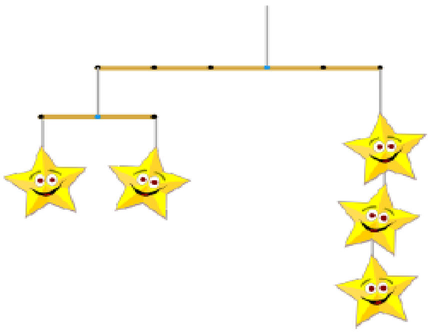
A = add(cube, cube)
B = add(A, cylinder)
C = turn(B)
D = add(C, cylinder)

D

A = add(cube, cylinder)
B = add(A, cylinder)
C = turn(B)
D = add(C, cylinder)
E = add(D, cylinder)

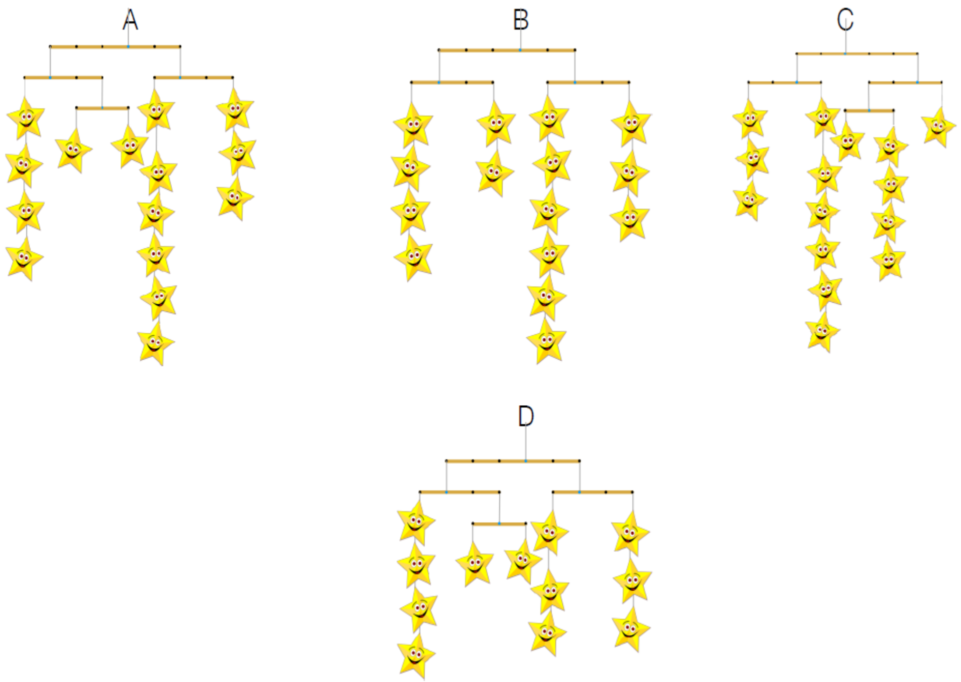
GENERALISATION – MOBILES

(-3 (-1 1) (1 1)) (2 3)



Which of the following mobiles could be constructed using these instructions:

(-3 (-1 4) (2 (-1 1) (1 1))) (2 (-1 6) (2 3))



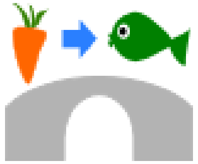
Generalisation is associated with identifying patterns, similarities and connections, and exploiting those features. It is a way of quickly solving new problems based on previous solutions to problems, and building on prior experience.

Beaver machine 2018-HU-03

Miley sits on top of the mountain. The mountain has three different waterfalls. The waterfalls flow down through a river.

Miley can drop either a carrot or a fish in one of the waterfalls.

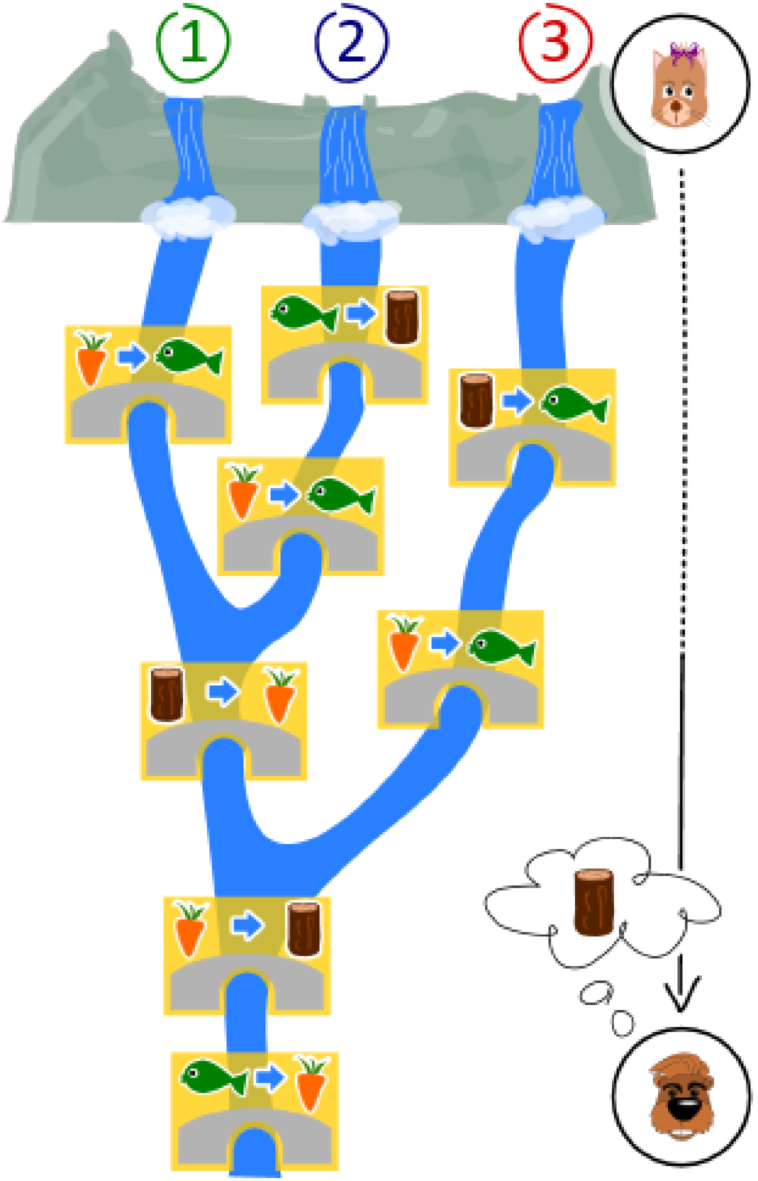
The river contains several bridges, each with trolls. The trolls replace items that pass under bridges.



For example, when a carrot passes under a bridge like the one above, the trolls replaces the carrot with a fish.

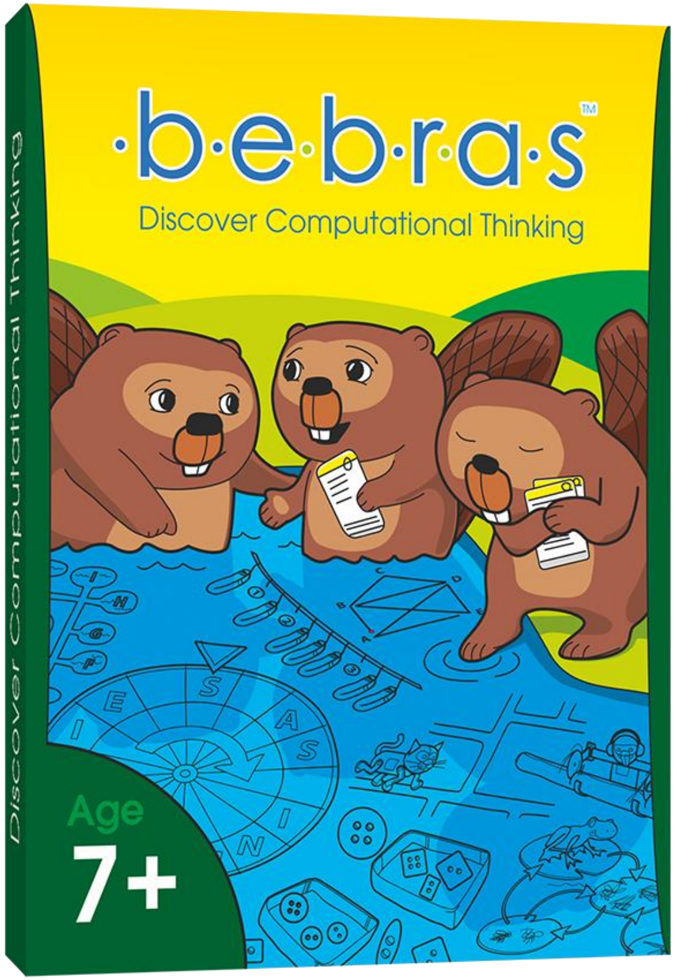
Justin Beaver sits at the end of the river.

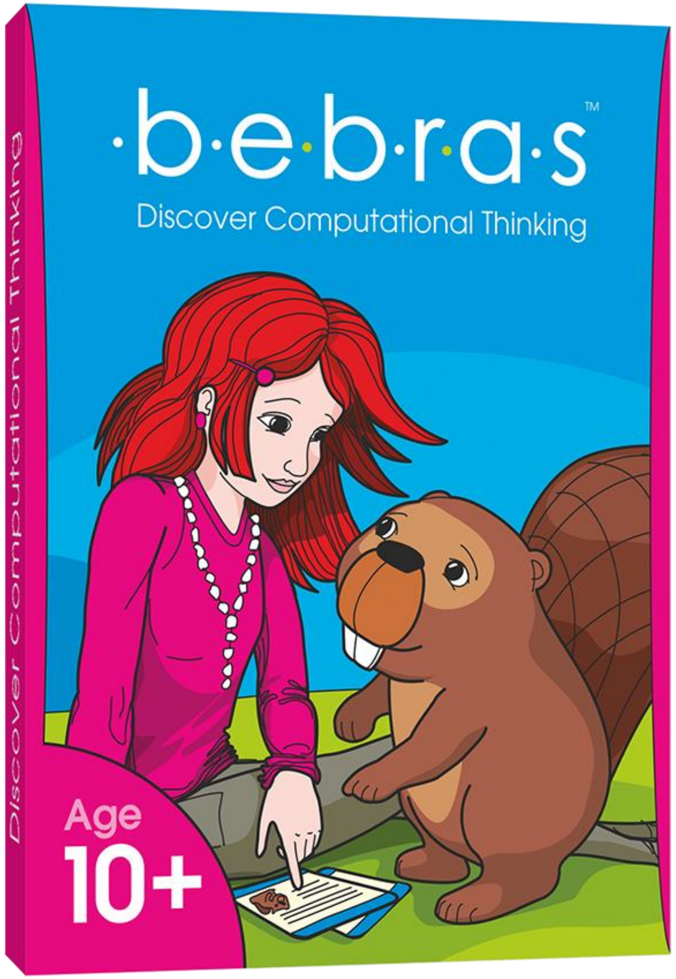
If Justin wants to receive wood, which item should Miley drop and where should she drop it in?

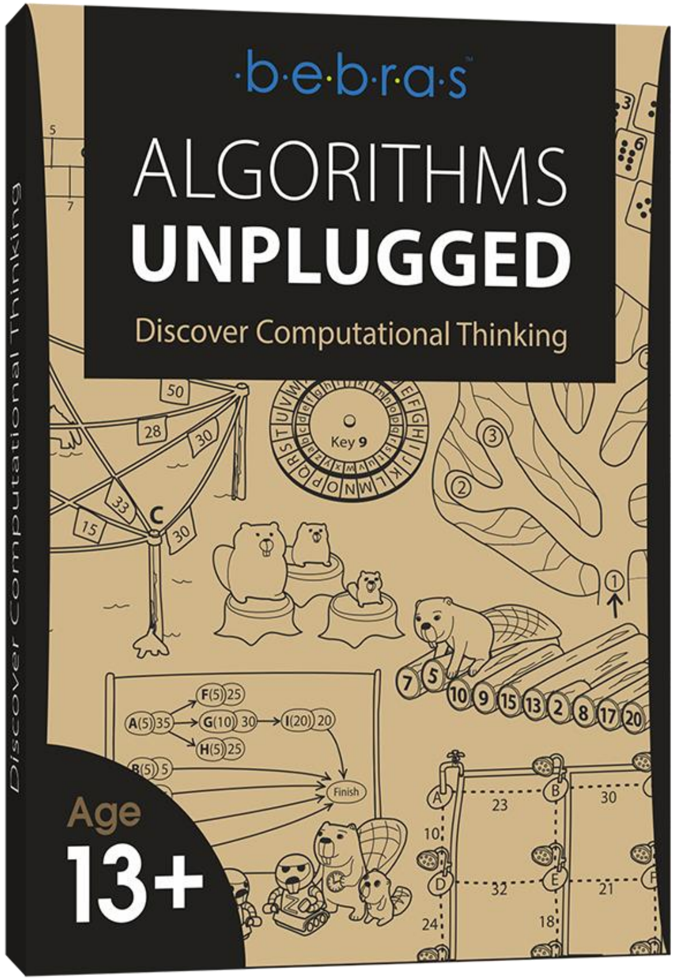


You can think of a computer as a device that reads *input* and writes *output*. How does a computer "know" what to do? The answer is that humans tell it what to do beforehand!

Task cards BEBRAS







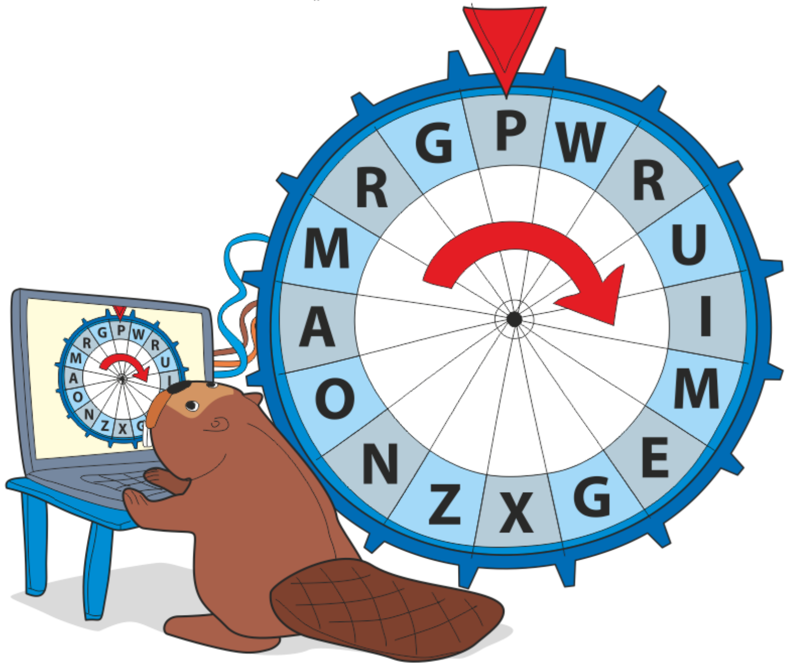
Abstraction	Identifying and extracting relevant information to define main ideas. Abstraction is simplifying things by removing unnecessary detail.
Logics	The study of reasoning: predicting and analysing. Helping us to try to make sense of things - to establish and check facts.
Data Analysis	The process 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.

TWO WORDS

A wheel is programmed to stop by the following rules:
1st time – skip one square,
2nd time – skip two squares,
3rd time – skip three squares, and so on.
The first letter in the word is „P ".



Can you read two words starting from „P"?

Informatics: command, execution, program, testing.
Computational thinking: abstraction, algorithms.

35

17 COLOURFUL TOWER

A little beaver girl put rings on the top of each other in this sequence:

1) Red
2) Green
3) Yellow

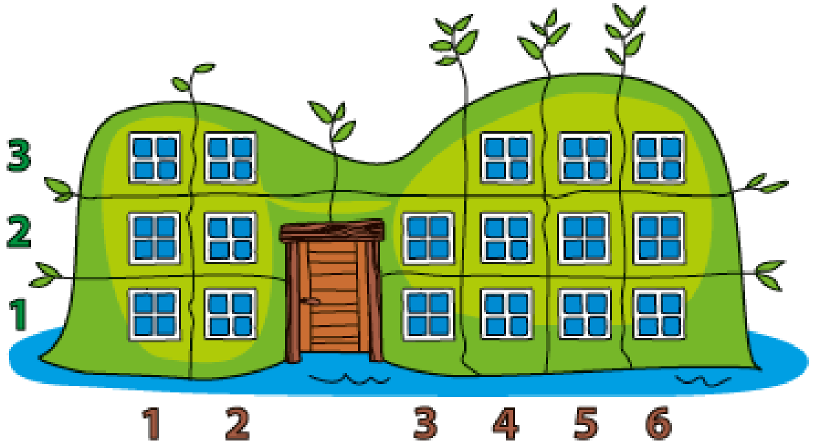
Repeats till the last correctly coloured ring.

How many rings will the tower have?

This game is one of the simplest examples of algorithm. 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 construct a robot to execute these commands.

44 BEAVERS HOUSE

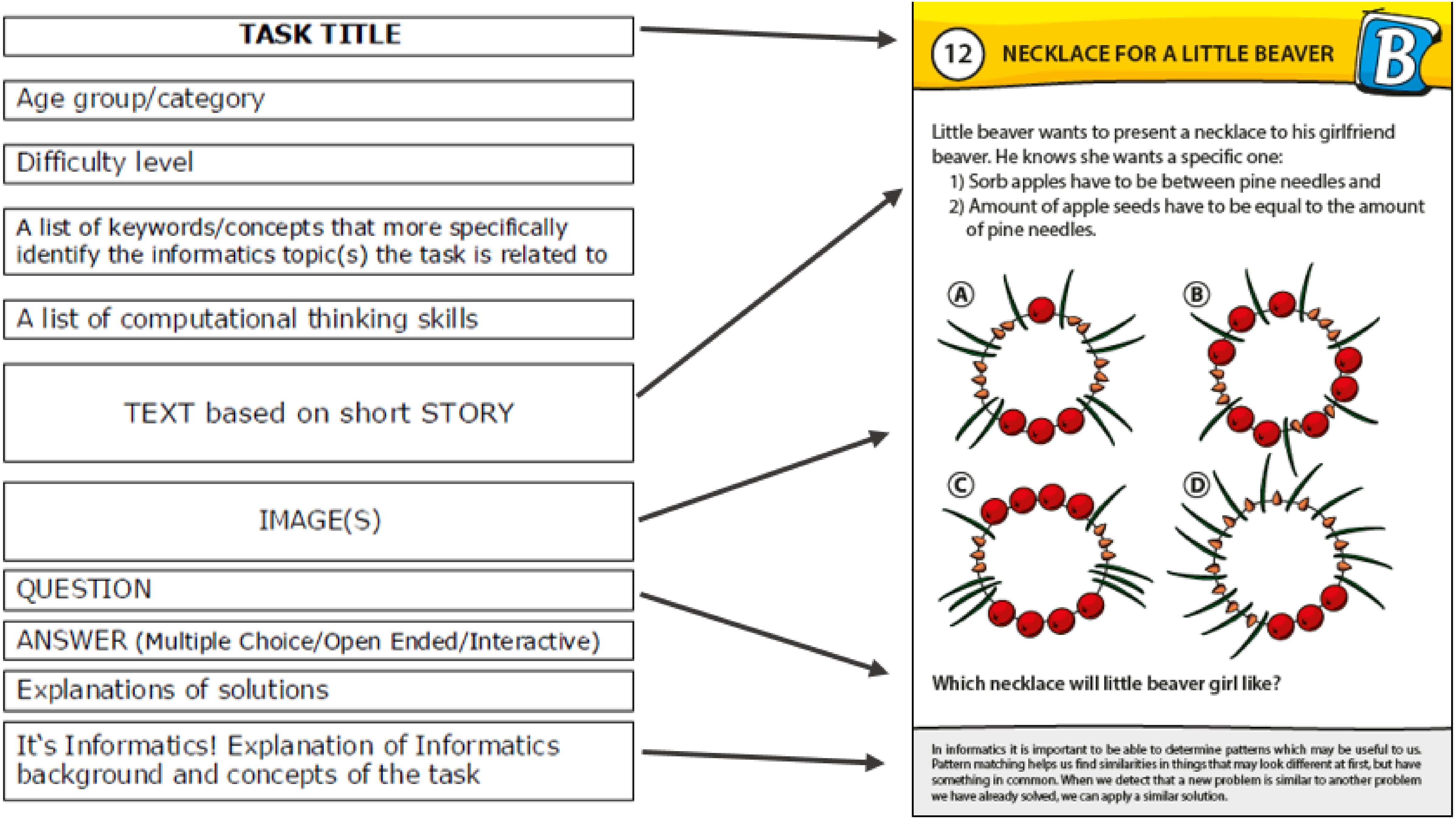
Beaver house windows are marked by row & column numbers, e.g. windows on the door's right: [1, 3] and [2, 3]. Beaver replaced windows: [1, 2]; [1, 6]; [2, 2]; [2, 5] last year.



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?

To identify a window there needs to be an agreement. When programming, it is best to lay out data in a table constructed from rows and columns: it is called an array. Every array element (table square) is indicated by a row and a column intersection number. It is possible to look at the beaver's house as an array and its elements (windows), which are identified by row and column numbers.

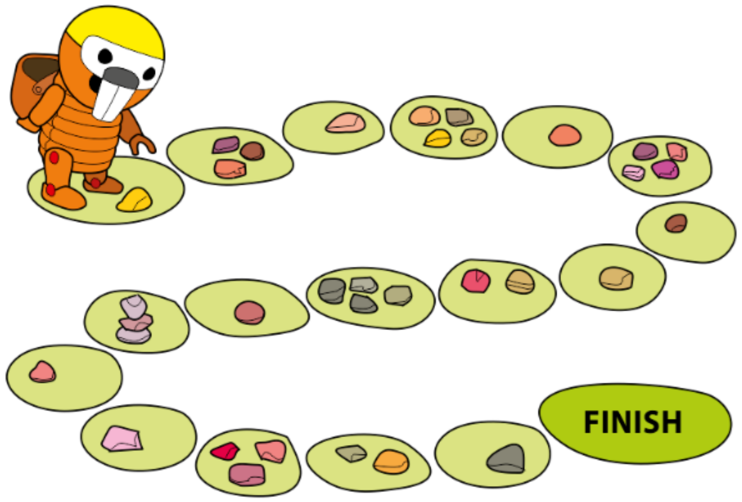

TASK TITLE
Age group/category
Difficulty level
A list of keywords/concepts that more specifically identify the informatics topic(s) the task is related to
A list of computational thinking skills
TEXT based on short STORY
IMAGE(S)
QUESTION
ANSWER (Multiple Choice/Open Ended/Interactive)
Explanations of solutions
It's Informatics! Explanation of Informatics background and concepts of the task
12
NECKLACE FOR A LITTLE BEAVER
B
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.
A
B
C
D
Which necklace will little beaver girl like?
In informatics it is important to be able to determine patterns which may be useful to us. Pattern matching helps us find similarities in things that may look different at first, but have something in common. When we detect that a new problem is similar to another problem we have already solved, we can apply a similar solution.

32 LITTLE STONES

Robot is collecting interesting stones by repeating the commands:

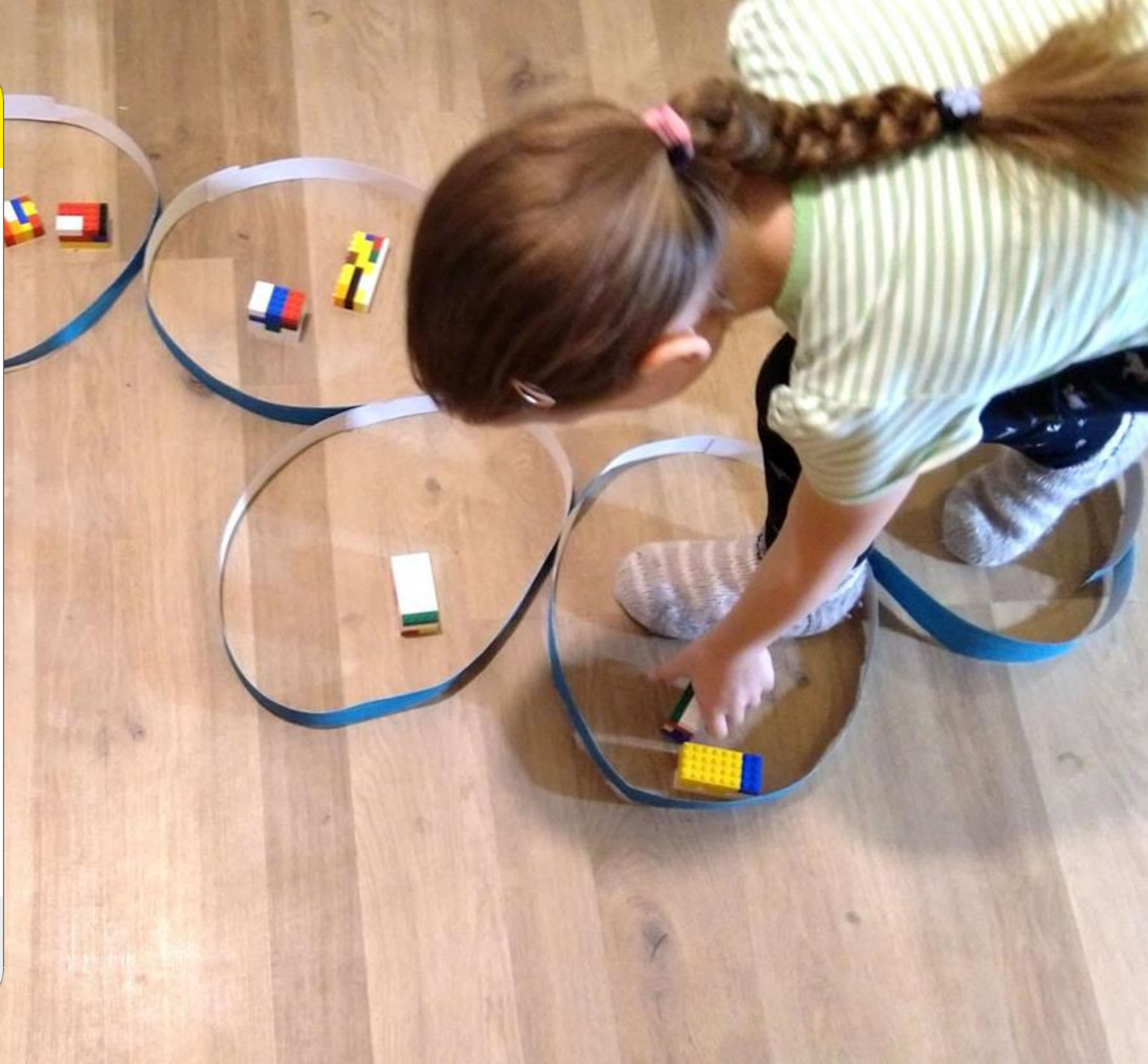
IF there is one stone in the square, then move to the next square,

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?

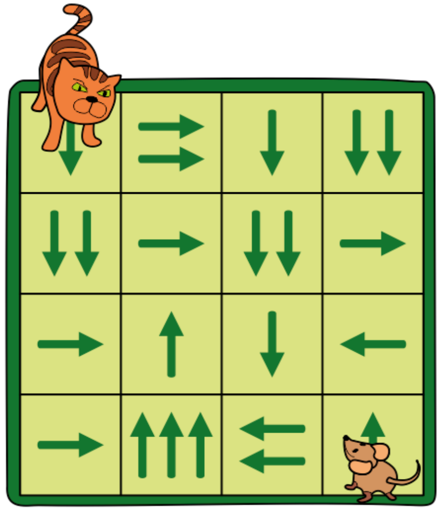
An important thing when you program is to write down the commands which do things you want to do. The selection command, presented here, is quite complex. Its condition is a number of little stones. If there is more than one stone, then two commands are implemented: take one little stone and move forward a number of squares.



24 CAT AND MOUSE

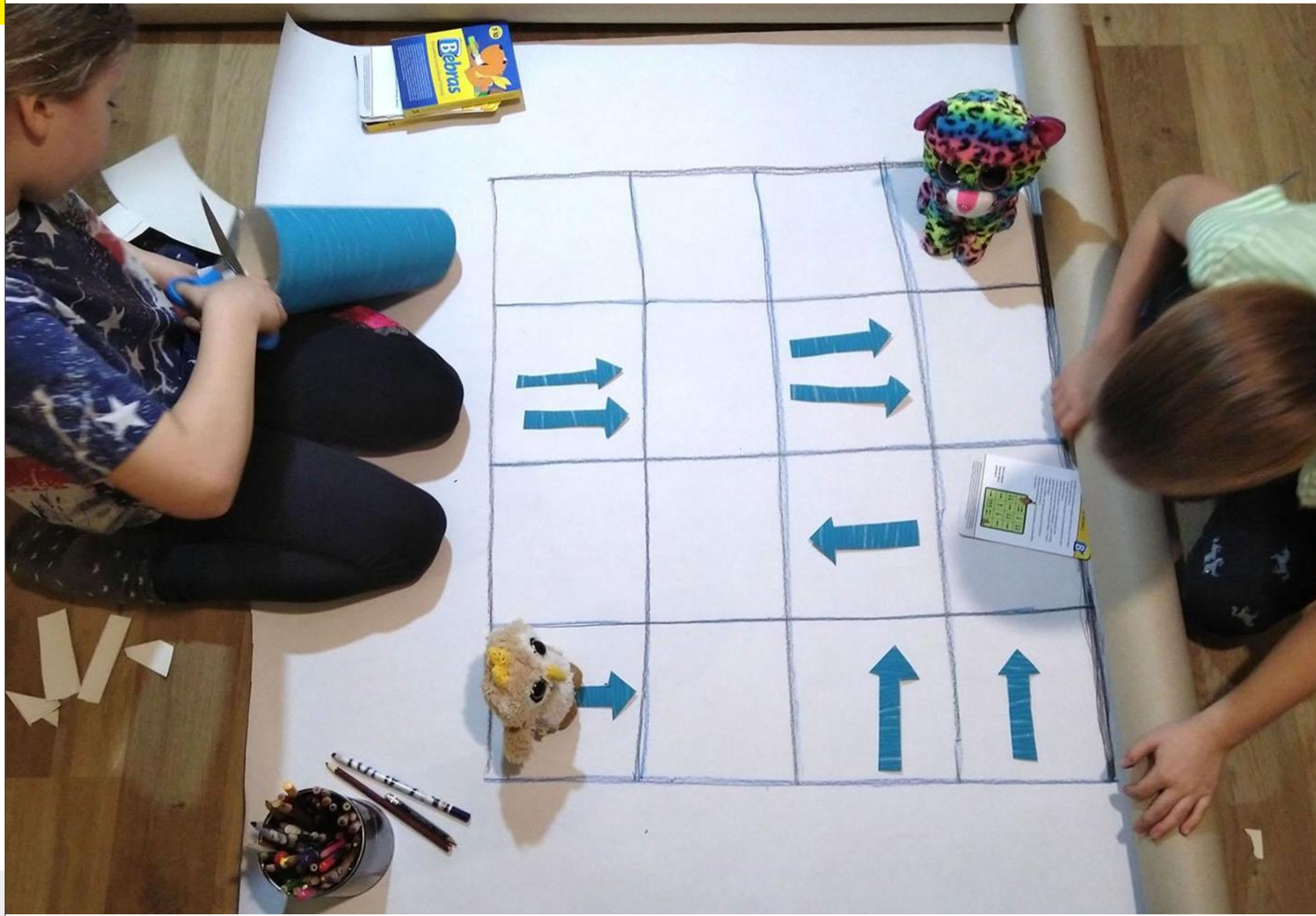
Beaver created two robots: cat and mouse. Both of them can move from one square to another following the arrows. Cat wants to hunt the mouse.

- 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.

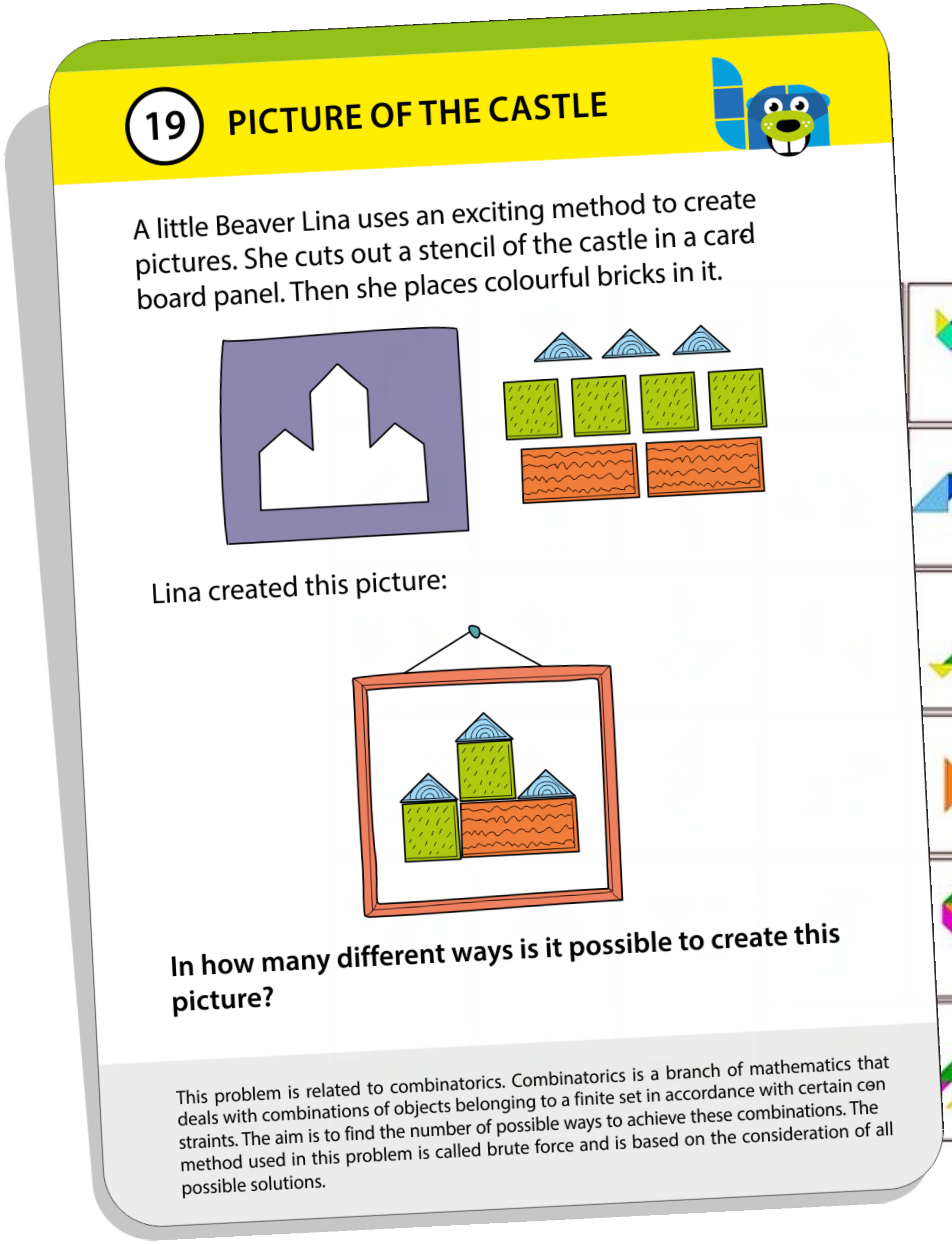


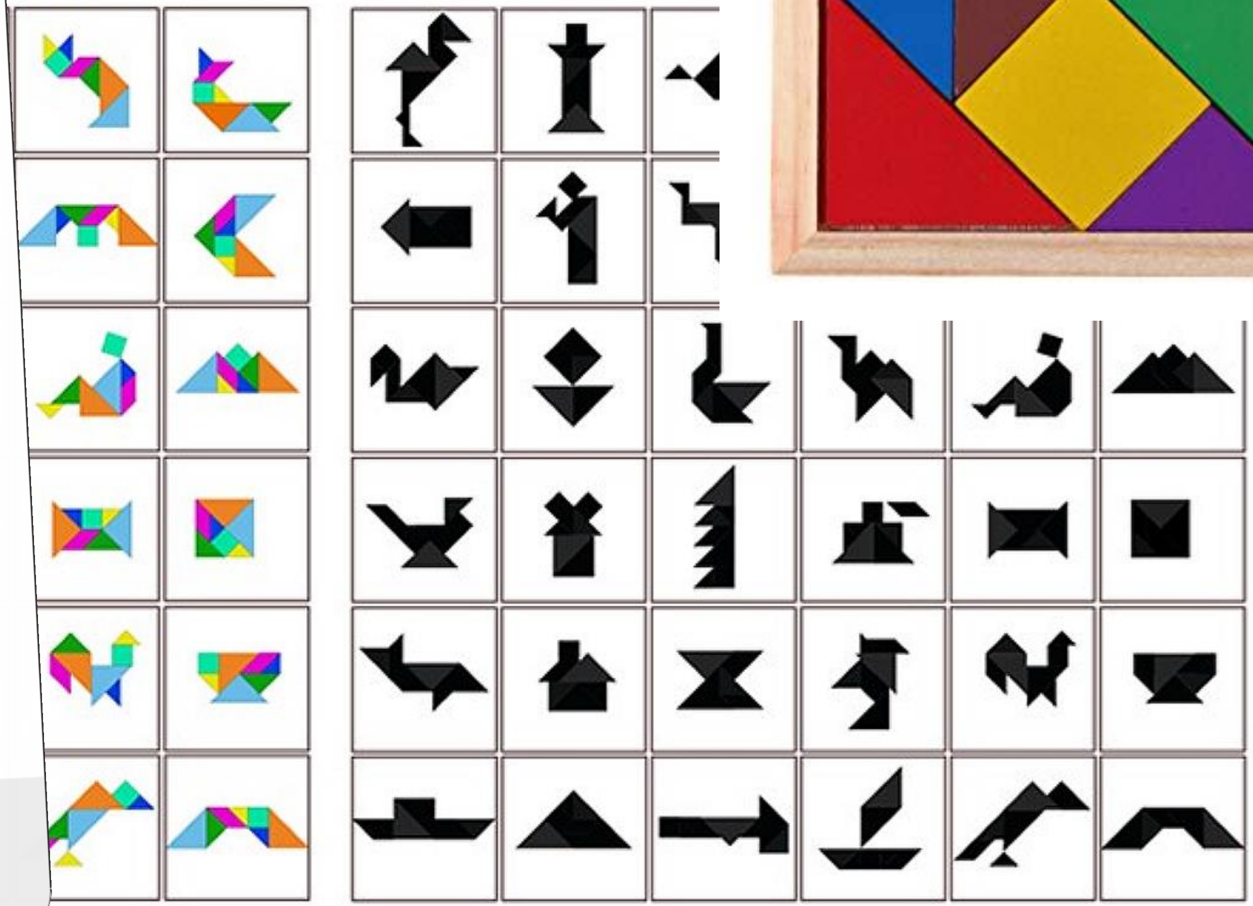
Can the mouse avoid?

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.



Tangram


19
PICTURE OF THE CASTLE
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 con-straints. 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!

KURIU IR MĄSTAU. Integruotos informatikos užduotys – smagių uždavinių rinkinys, padedantis žingsnelis po žingsnelio ugdyti informatinio mąstymo įgūdžius, reikalingus būsimiems kompiuterių, robotų, naujų išmaniųjų įrenginių kūrėjams.

Pagal projekto „Informatika pradiniame ugdyme" gaires parengtas leidinys yra susijęs su integruoto ugdymo vadovėliu „Vaivorykštė", todėl jame esančias užduotis galima įtraukti į pasaulio pažinimo, matematikos, gimtosios kalbos ar kitų mokomųjų dalykų turinį.

Leidinį papildo metodiškai paaiškinti užduočių sprendimai ir atsakymai, kuriuos galima rasti skaitmeninėje ugdymo priemonėje e.lankos (www.e-lankos.lt) arba leidyklos svetainėje (baltulankuvadoveliai.lt/kuriu-ir-mastau/).

Pradinėms klasėms skirtas
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Valentina Dagienė

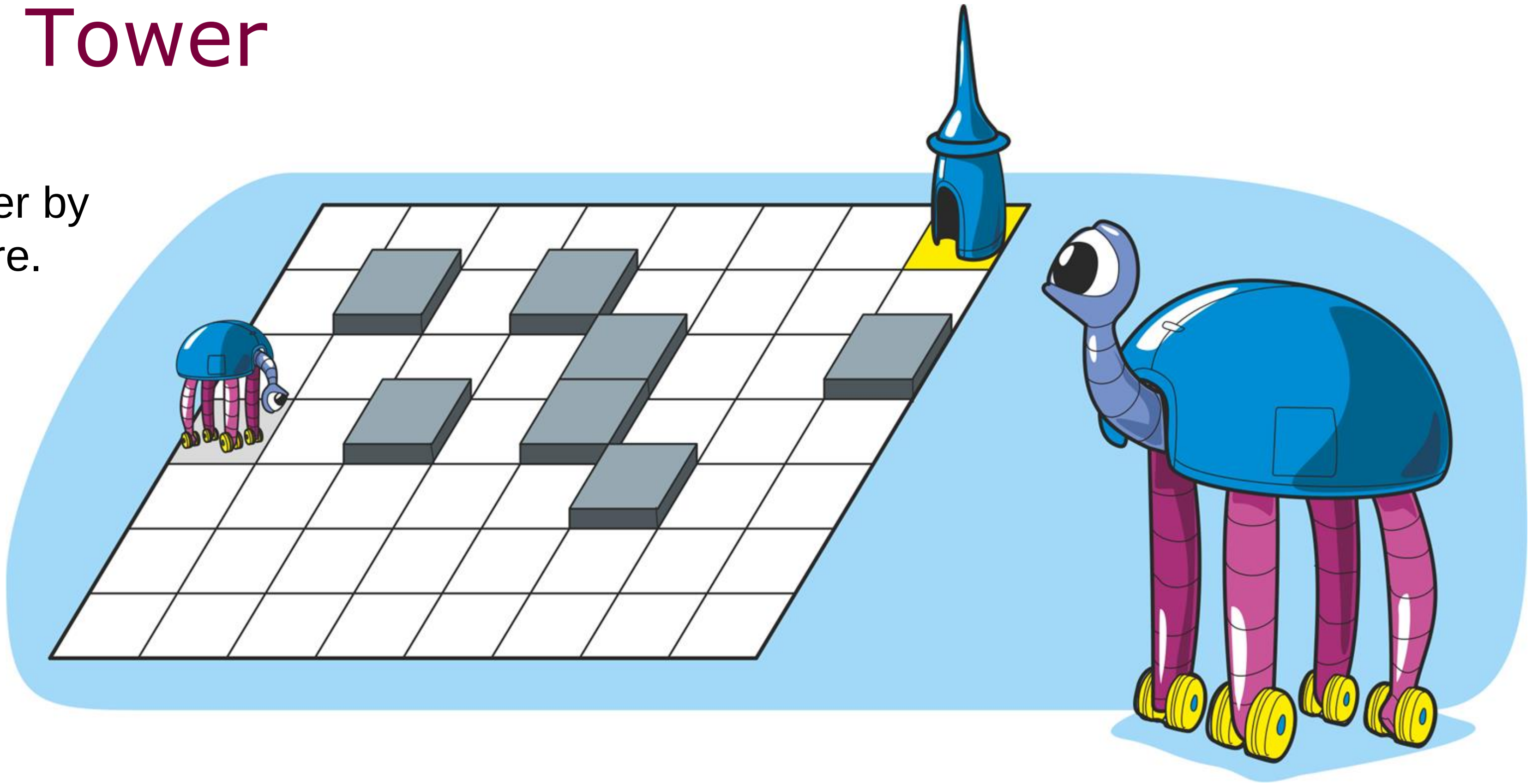
MĄSTAU IR KURIU

Integruotos informatikos užduotys 6–8 metų vaikams

baltos lankos

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

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