# Teaching Computational Thinking

Valentina Dagienė
valentina.dagiene@mii.vu.lt
Vilnius University

# Jeannette Wing suggested term CT (2006)

„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, 49(3), p. 33-35, 2006.

# Definition by CSTA and ISTE of CT suitable for use in K-12 education, identifying nine essential categories

- data collection
- data analysis
- data representation
- problem decomposition
- abstraction
- algorithms
- automation
- parallelization
- simulation

ISTE Computational thinking for all http://www.iste.org/learn/computational-thinking

Starting from practical examples identify the terms:

- **abstraction,**
- **automation,**
- **analysis**

as being particularly useful to understand how young pupils can deal with novel problems.

They also propose the use/modify/create progression for the engagement with complex CS environments.

| CT Concept, Capability | Informatics |
| --- | --- |
| Data collection | Find a data source for a problem area |
| Data analysis | Write a program to do basic statistical calculations on a set of data |
| Data representation | Use data structures such as array, linked list, stack, queue, graph, hash table |
| Problem decomposition | Define objects and methods; define main and functions |
| Abstraction | Use procedures to encapsulate a set of often repeated commands that perform a function; use conditionals, loops, recursion, |
| Algorithms & procedures | Study classic algorithms; implement an algorithm for a problem area |
| Automation | Run programs |
| Parallelization | Threading, pipelining, dividing up data or task in such a way to be processed in parallel |
| Simulation | Algorithm animation, parameter sweeping |

# Operational definition by ISTE for CT as a problem-solving process with 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 ordered 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

## EXAMPLES OF CT IN THREE DOMAINS

| | Abstraction | Automation | Analysis |
|---|---|---|---|
| Modeling & Simulation | Selecting features of real-world to incorporate in a model | Time stepping using a model as an experimental testbed | Were the correct abstractions made?<br>Does the model reflect reality? |
| Robotics | Design robot to react to a set of conditions | Program checks sensors to monitor conditions | Are there situations that were not taken into account? |
| Game Design & Development | Games are abstracted into a set of scenes containing characters | Game responds to user actions | Do the elements incorporated make the game fun to play? |

Taken from: Lee et al, Computational thinking for youth in practice, *ACM Inroads*, 2:1, March 2011, pp. 32-37, http://dl.acm.org/citation.cfm?id=1929902

# CT through events and activities

- CS Unplugged
- Bebras
- CS4FN
- RoboCup Junior
- FIRST LEGO  League
- Hour of Code
- European Code Week
- …

# Computer programming and coding

## Priorities, school curricula and initiatives across Europe

Anja Balanskat, Katja Engelhardt. “Computing our future“. European Schoolnet, October 2015

*“Today, computer programs are the genetic code of our world — and many educators (as well as parents, economists, and politicians willing to entangle themselves in education matters) are starting to think that students need more than a passing knowledge of computer coding. They see it as both a powerful language students can tap into that solves just about any kind of problem and an elemental structure of modern society they simply need to understand.”*

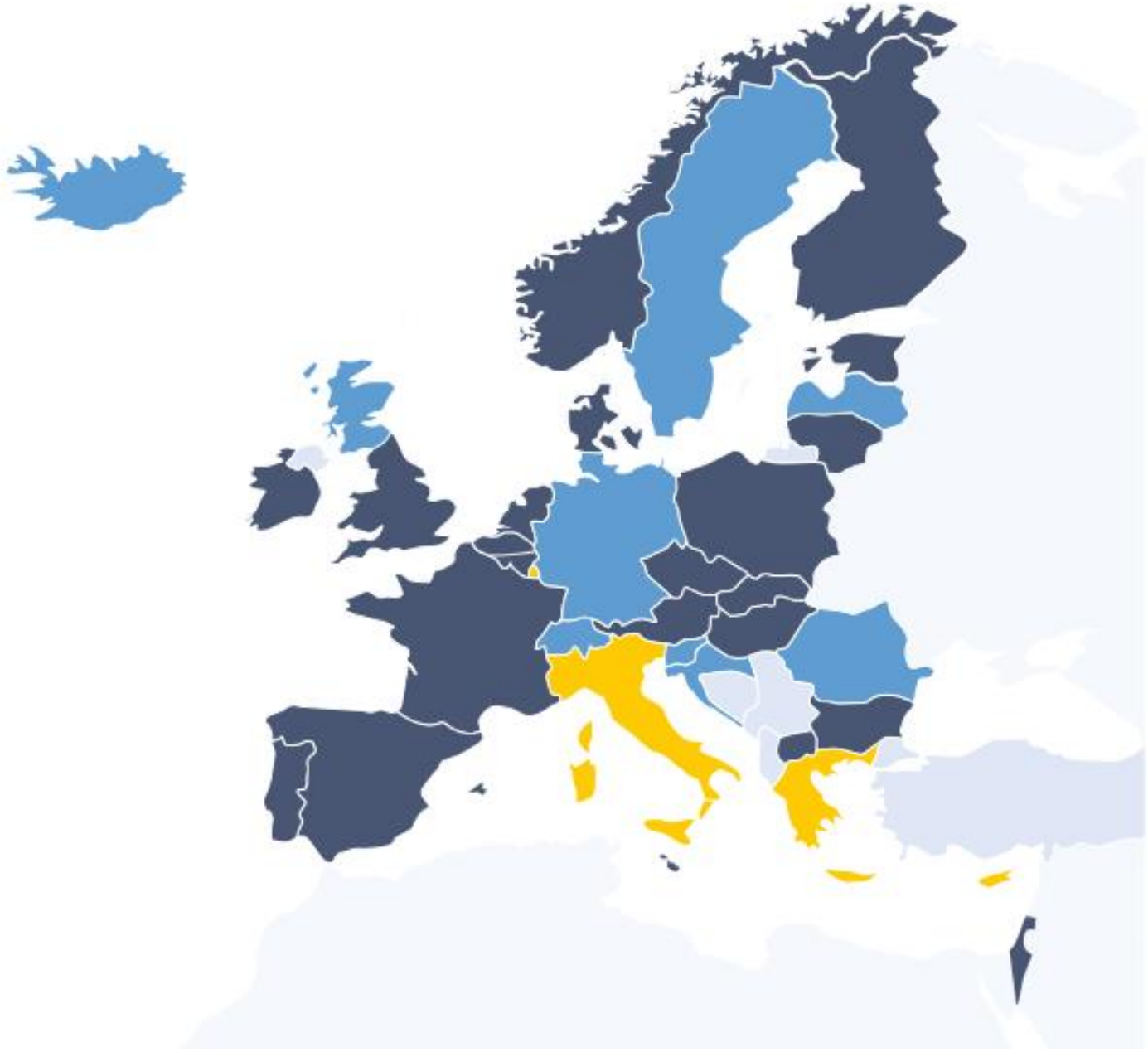
Peter Gow, 2015

# Introduction

- Many educators, as well as parents, economists and politicians in Europe and worldwide are starting to think that students need some computing and coding skills.
- By 2020, Europe may experience a shortage of more than 800,000 professionals skilled in computing/informatics.
- Coding skills help to understand today's digitalised society and foster 21st century skills like problem solving, creativity and logical thinking.

# Participating countries

- 21 Ministries of Education, or organisations nominated to act on their behalf, contributed to this overview of current initiatives and plans:
- Austria (AT),
- Belgium Flanders (BE (NL)),
- Belgium Wallonia (BE (FR)),
- Bulgaria (BG),
- Czech Republic (CZ),
- Denmark (DK),
- Estonia (EE),
- Finland (FI),
- France (FR),
- Hungary (HU),
- Ireland (IE),
- Israel (IL),
- Lithuania (LT),
- Malta (MT),
- the Netherlands (NL),
- Norway (NO), Poland (PL),
- Portugal (PT),
- Slovakia (SK),
- Spain (ES)
- United Kingdom (UK (England)).



21 countries participated in the survey

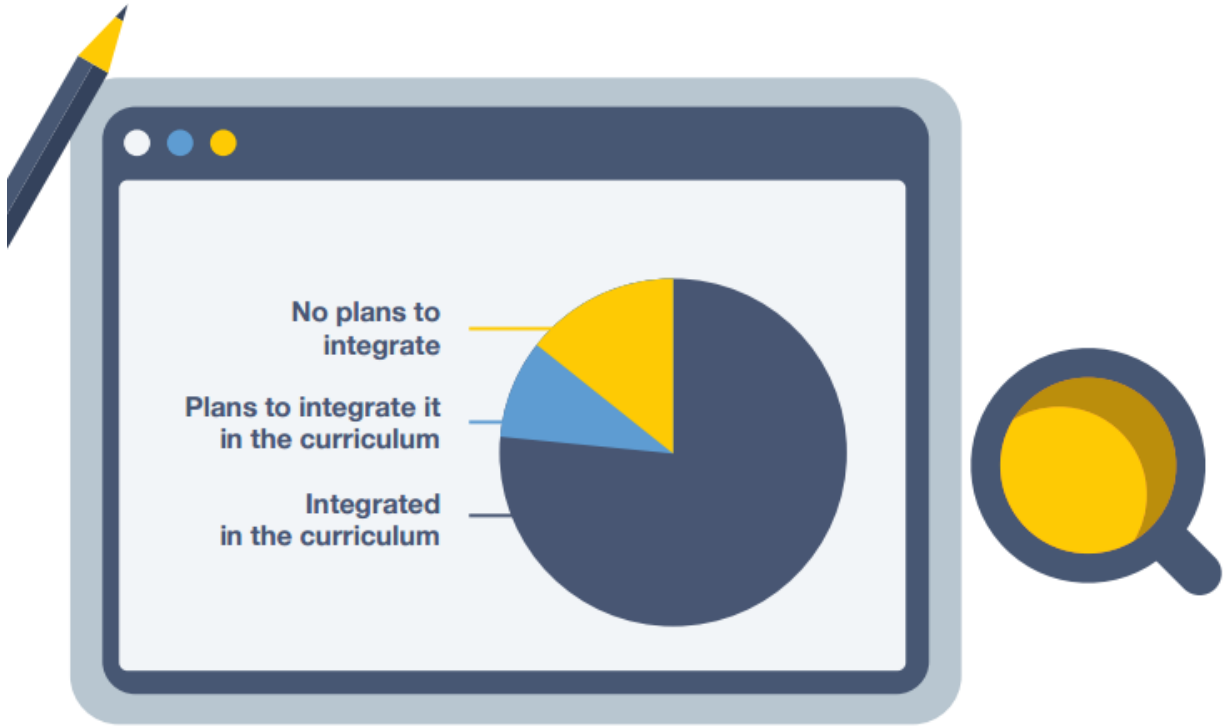
No information

Countries, which only participated in the 2014 report

# The report focuses on the following main questions

- What is the Ministry of Education's current thinking about this topic? Which terms are used in the national, regional or local curricula? Which are the current priorities in ICT competence development including programming and coding?
- Is computer programming or coding already part of the school curriculum and how is it integrated? What activities are required and what competences are developed? How are these assessed?
- Are there any plans to integrate computer programming and coding in school curricula in the future?
- What current or planned training provision is there to support teachers who teach computing and coding?
- Are there any school pilots or computer coding initiatives and what are the main actors involved?
- Does your country have a digital skills/competences strategy for education?
- Are there evaluations of coding initiatives/pilots in your country?
- Are there any examples of good practice of coding initiatives in your country?

# Integrating coding skills in the curriculum

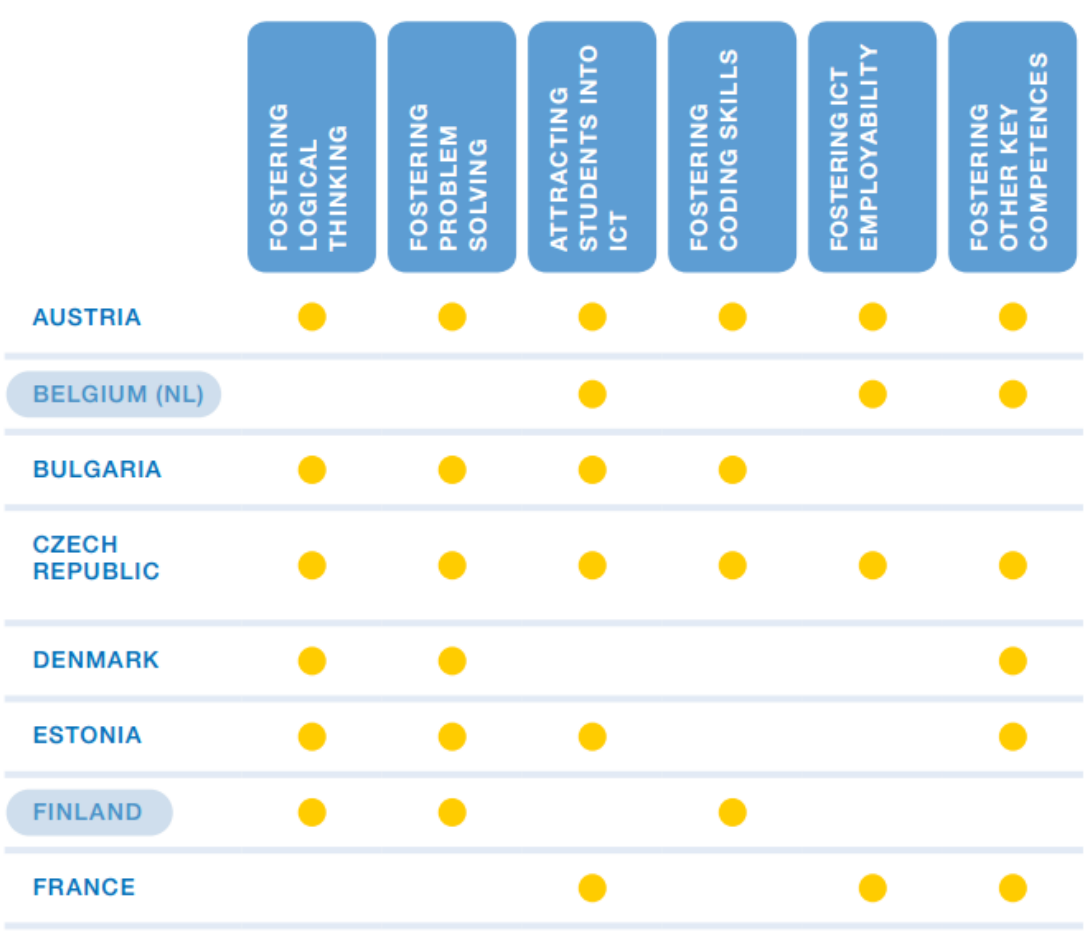


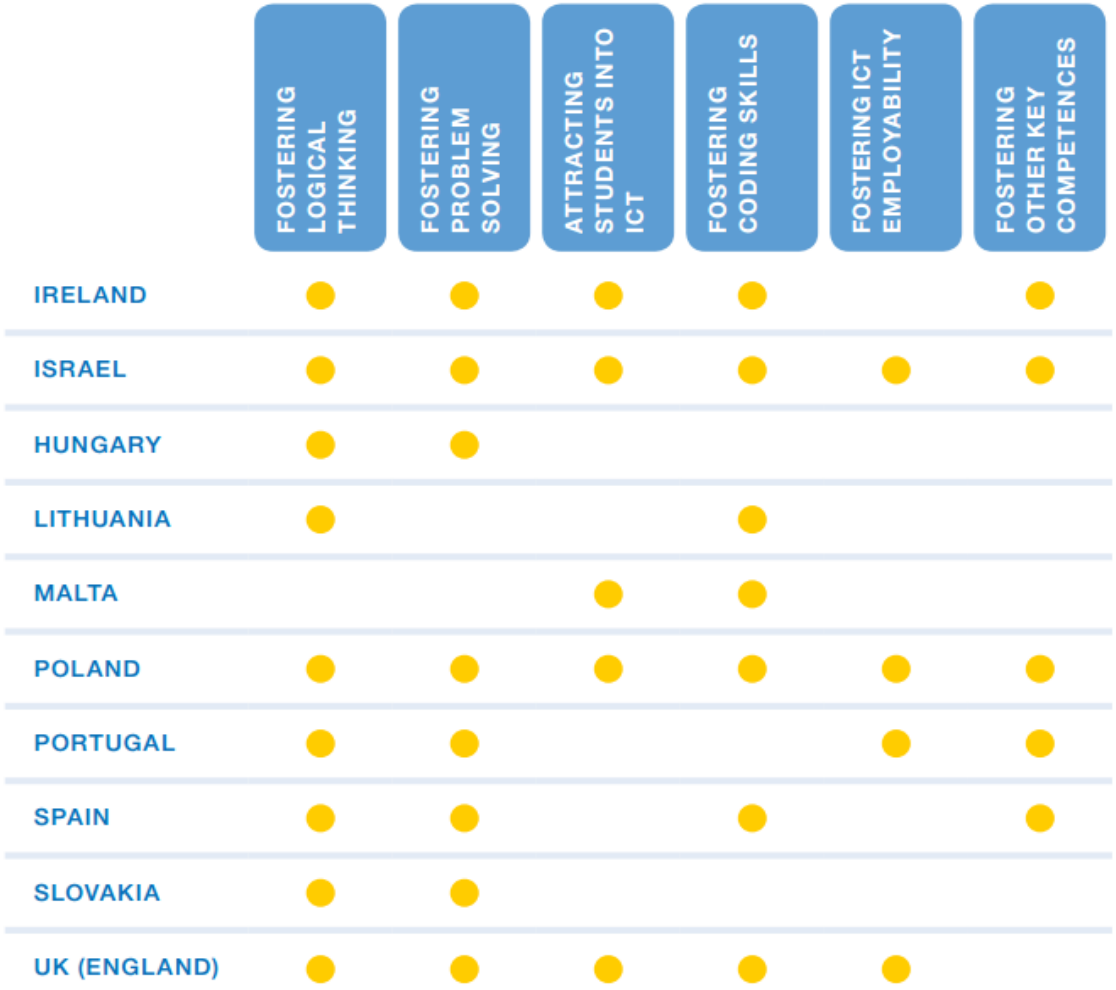

AUSTRIA, BULGARIA, THE CZECH REPUBLIC, DENMARK, ESTONIA, FRANCE, HUNGARY, IRELAND, LITHUANIA, MALTA, SPAIN, POLAND, PORTUGAL, SLOVAKIA, THE UK (ENGLAND), ISRAEL

BELGIUM FLANDERS, FINLAND

BELGIUM WALLONIA, NETHERLANDS, NORWAY

# Rationale for integrating coding in the curriculum

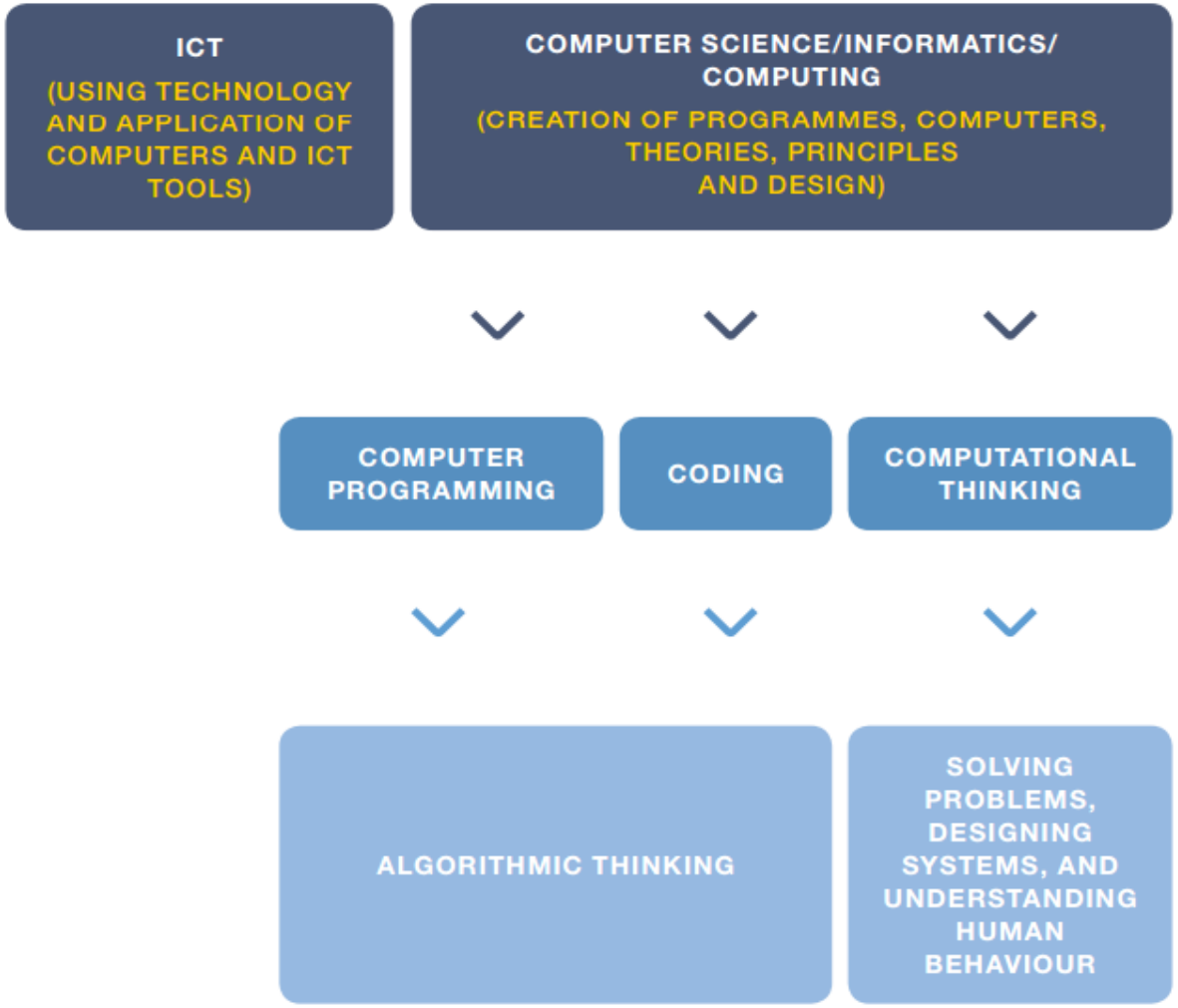


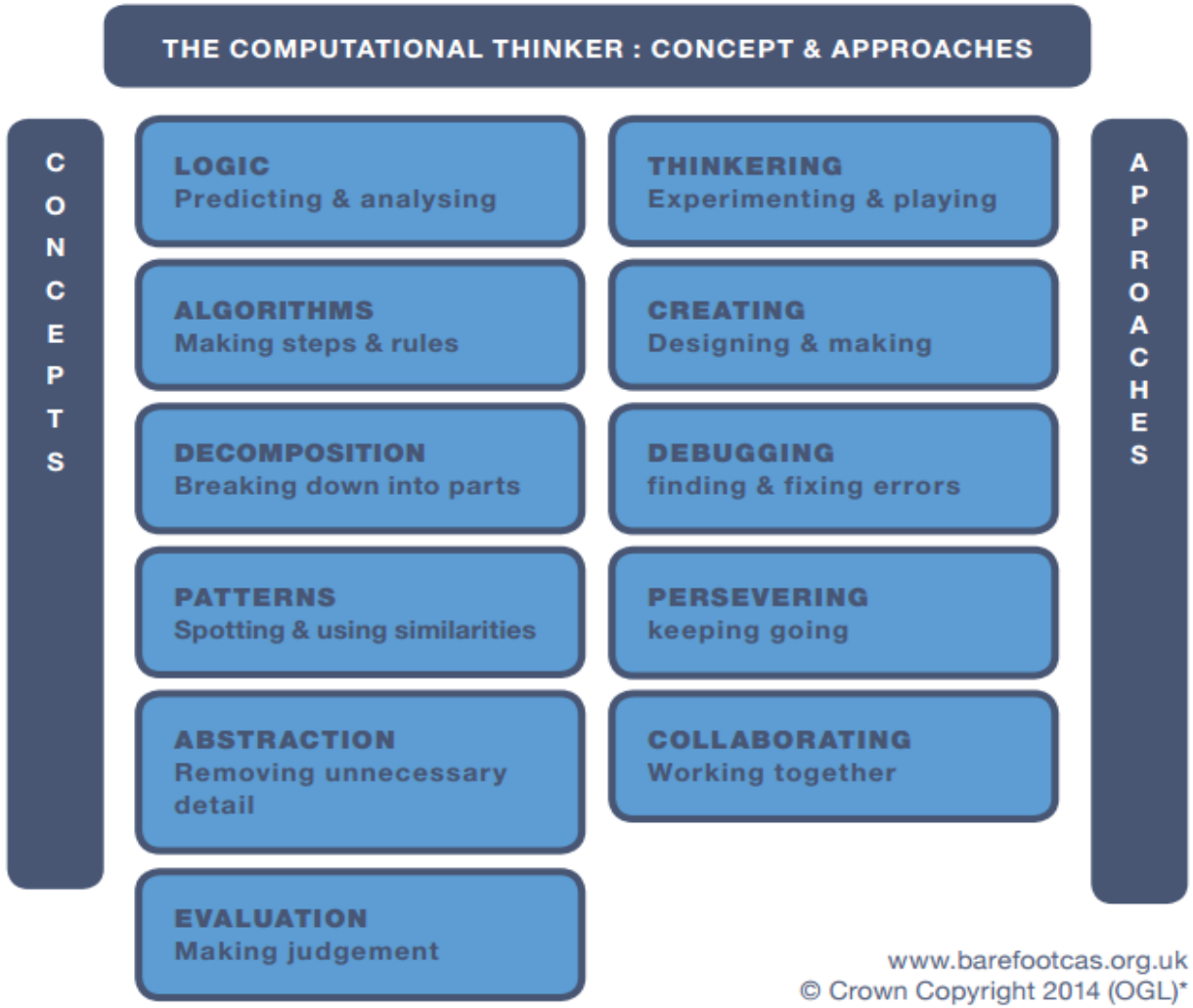
# Terms used for coding

- Programming (BE (FL), DK, EE, ES, FI, HU, NL, NO, PL, PT, SK) and computing (UK (England)) are the most common terms used by countries.
- Coding and computer programming are used interchangeably in Poland, England, Norway and NL.
- Some countries additionally use the terms algorithmic applications (IL), algorithmic problem solving (SK) or algorithm design and data models (HU), or algorithmic and robotics (ES).
- Ireland and France exclusively refer to coding.
- **Computational thinking** is referred to by Belgium Flanders, the Czech Republic, Ireland, Malta, Netherlands, and Poland.

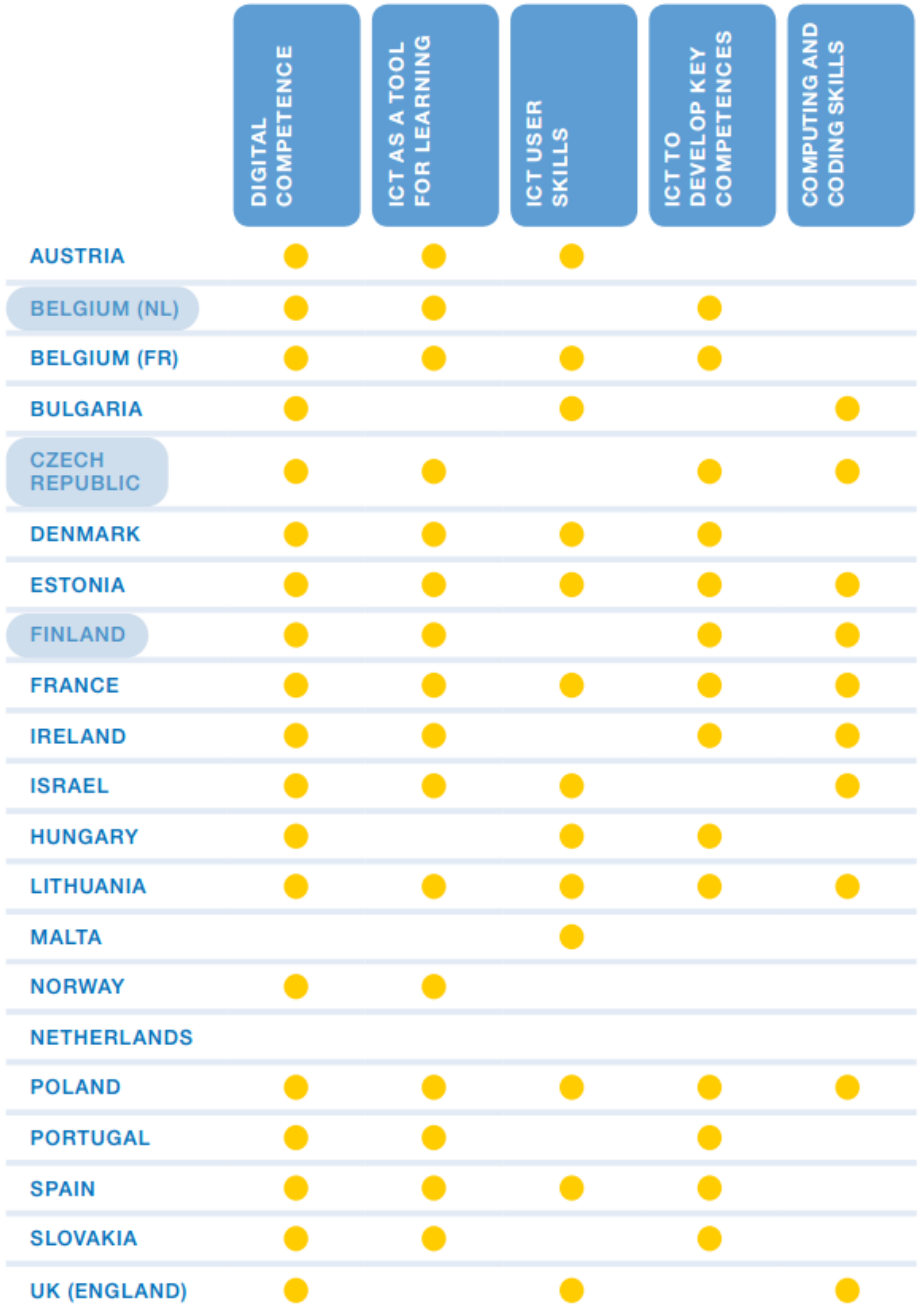
# Distinction between ICT and technology, and computer science



# Concepts and approaches of computational thinking

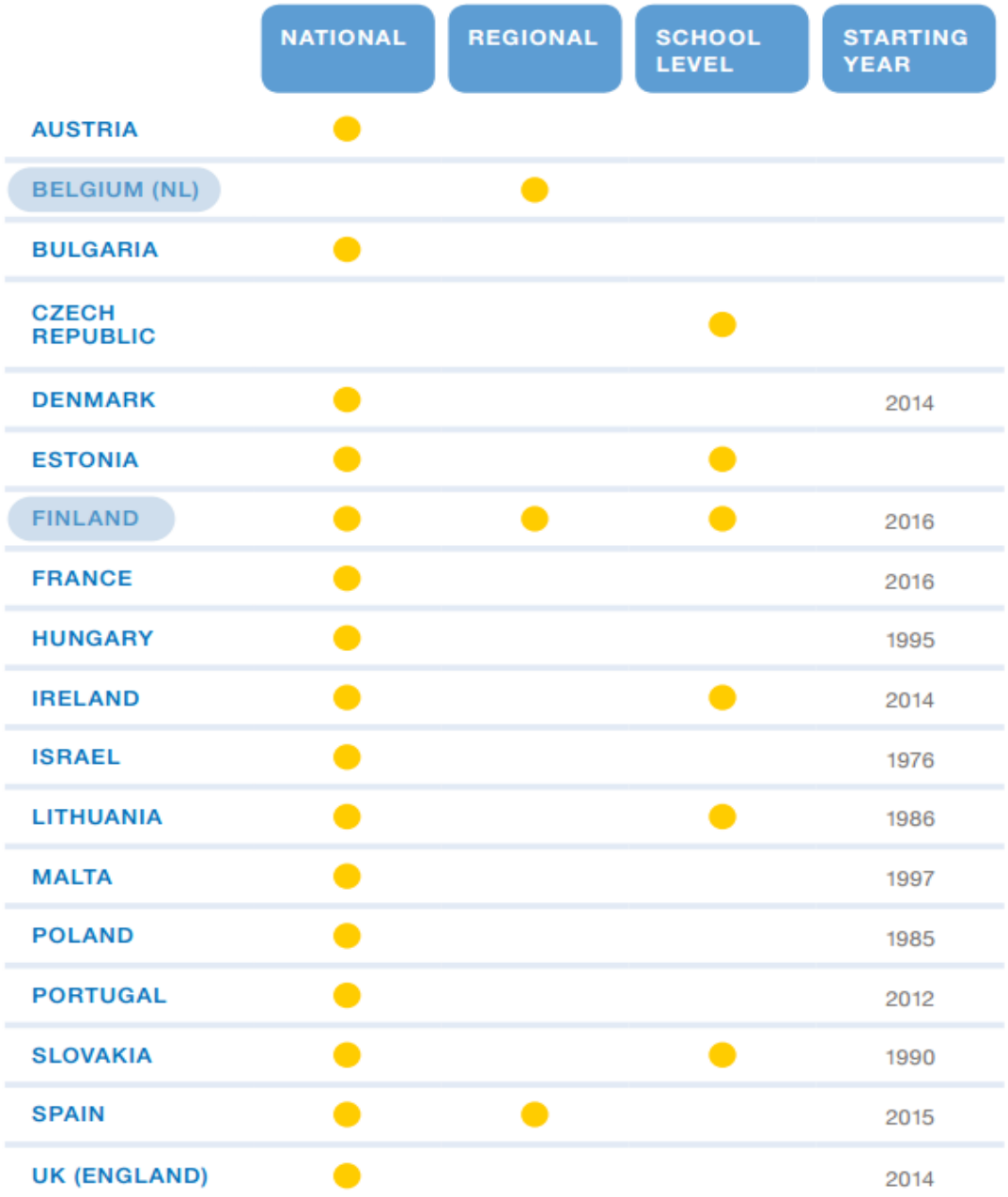


# ICT skill priorities



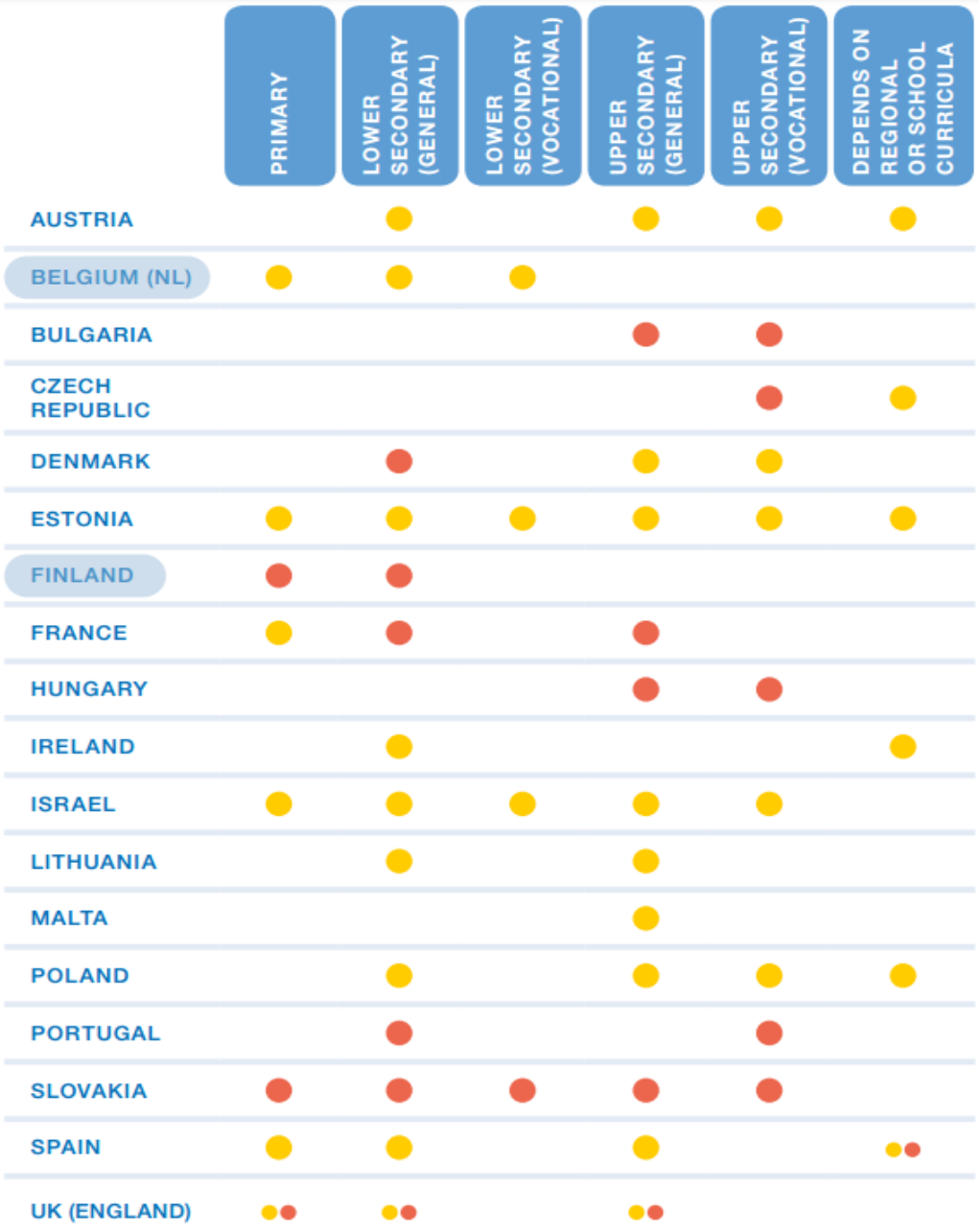
| | DIGITAL COMPETENCE | ICT AS A TOOL FOR LEARNING | ICT USER SKILLS | ICT TO DEVELOP KEY COMPETENCES | COMPUTING AND CODING SKILLS |
|---|---|---|---|---|---|
| AUSTRIA | ● | ● | ● | | |
| BELGIUM (NL) | ● | ● | | ● | |
| BELGIUM (FR) | ● | ● | ● | ● | |
| BULGARIA | ● | | ● | | ● |
| CZECH REPUBLIC | ● | ● | | ● | ● |
| DENMARK | ● | ● | ● | ● | |
| ESTONIA | ● | ● | ● | ● | ● |
| FINLAND | ● | ● | | ● | ● |
| FRANCE | ● | ● | ● | ● | ● |
| IRELAND | ● | ● | | ● | ● |
| ISRAEL | ● | ● | ● | | ● |
| HUNGARY | ● | | ● | ● | |
| LITHUANIA | ● | ● | ● | ● | ● |
| MALTA | | | ● | | |
| NORWAY | ● | ● | | | |
| NETHERLANDS | | | | | |
| POLAND | ● | ● | ● | ● | ● |
| PORTUGAL | ● | ● | | ● | |
| SPAIN | ● | ● | ● | ● | |
| SLOVAKIA | ● | ● | | ● | |
| UK (ENGLAND) | ● | | ● | | ● |

# Level of curriculum integration (current and future)



| | NATIONAL | REGIONAL | SCHOOL LEVEL | STARTING YEAR |
|---|---|---|---|---|
| AUSTRIA | ● | | | |
| BELGIUM (NL) | | ● | | |
| BULGARIA | ● | | | |
| CZECH REPUBLIC | | | ● | |
| DENMARK | ● | | | 2014 |
| ESTONIA | ● | | ● | |
| FINLAND | ● | ● | ● | 2016 |
| FRANCE | ● | | | 2016 |
| HUNGARY | ● | | | 1995 |
| IRELAND | ● | | ● | 2014 |
| ISRAEL | ● | | | 1976 |
| LITHUANIA | ● | | ● | 1986 |
| MALTA | ● | | | 1997 |
| POLAND | ● | | | 1985 |
| PORTUGAL | ● | | | 2012 |
| SLOVAKIA | ● | | ● | 1990 |
| SPAIN | ● | ● | | 2015 |
| UK (ENGLAND) | ● | | | 2014 |

# Integration by level of education



# Curriculum location and integration

- 12 have established a specific coding/computing subject in the curriculum, at national, but also at regional or school level only.
- 13 countries integrate coding in a general ICT/technology course, 7 of them depending on regional or school curricula.
- Increasingly coding is also integrated in other subjects (mainly mathematics) as a cross-curricular approach, e.g. in Denmark, Estonia, Finland, Slovakia, Spain and France. Finland will be the first country to introduce coding in a purely cross-curricular approach

# Assessment of coding skills

- Almost all countries assess coding competences (Austria, Bulgaria, Denmark, France, Hungary, Ireland, Israel, Lithuania, Malta, Poland, Portugal, Slovakia, Spain).
- In Estonia, this depends on regional or school curricula.
- In most countries, the assessment forms part of the general assessment of the students, e.g. exams (Austria, Bulgaria, Slovakia), school-leaving exams (Denmark, Israel, Lithuania, Poland) or also project work (Ireland, Israel, Malta)

# Evaluations of coding initiatives

- Only in the Czech Republic, Denmark, Hungary, Israel, Malta and Spain, evaluations of coding initiatives/pilots are already carried out.

# Teacher training and initiatives

- 13 of the countries which integrate coding in the curriculum already offer in-service and/or pre-service training to support teachers in teaching coding at various levels (Austria, Bulgaria, France, Estonia, Hungary, Ireland, Israel, Malta, Poland, Portugal, Slovakia, Spain, UK (England)).
- In addition, many countries support teachers by providing educational resources on their national or regional portals (e.g. Ireland, Belgium Flanders, Estonia, Netherlands); other countries promote specific coding websites and community platforms (e.g. Bulgaria, France, Norway, Poland).
- Several countries also support European-wide initiatives like the "CodeWeek" in their country, e.g. the Czech Republic, Poland, Portugal and Spain.

*“I t also has to be noted that there is a gap in the digital competences of teaching staff which needs to be addressed if the teacher is to feel comfortable in front of an audience which is increasingly technology-enabled”*

James Catania (2014): Computing as a Core Entitlement, Maltese Ministry of Education and Employment

Some references:


- A. Balanskat, K. Engelhardt. Computing our future. Computer programming and coding: Priorities, school curricula and initiatives across Europe. European Schoolnet, October 2015. http://fcl.eun.org/documents/10180/14689/Computing+our+future_final.pdf/746e36b1-e1a6-4bf1-8105-ea27c0d2bbe0
- V. Barr, C. Stephenson. Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community? *ACM Inroads*, 2(1): p. 48-54, 2011.
- K. Brennan, M. Resnick. New frameworks for studying and assessing the development of computational thinking. Proc. of the annual meeting of the American Educational Research Association, 2012.
- Exploring Computational Thinking. http://www.google.com/edu/computationalthinking
- ISTE Computational thinking for all. http://www.iste.org/learn/computational-thinking
- L. Mannila, V. Dagiene, et all. Computational Thinking in K-9 Education. Proc. of the WG Reports of the ITiCSE Conference, p. 1-29, 2014. http://dl.acm.org/citation.cfm?id=2713610
- J. M. Wing. Computational thinking. Communications of the ACM, 49(3), 33-35, 2006.
- J. M. Wing. Computational Thinking: What and Why, 2011. http://www.cs.cmu.edu/link/researchnotebook-computational-thinking-what-and-why

# Thank you!