Vilnius University

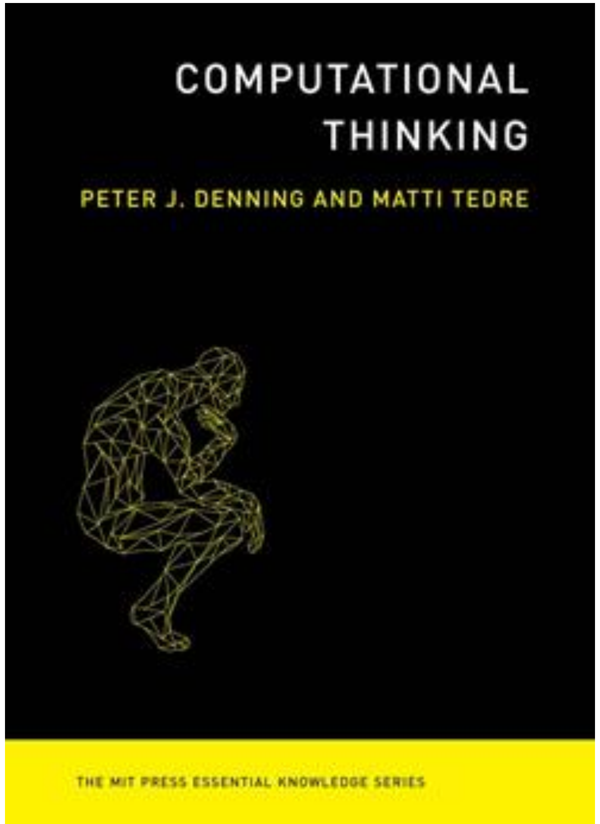
Informatics Education Across Europe: Emerging Trends, Challenges, and Personal Insights

Valentina Dagienė

Unpacking terminology

- Computer Science (CS)
  - The study of computers and algorithmic processes, including principles, hardware and software designs, applications, and impact on society
- Computing
  - Computational methods, models, and systems, such as information manegemant, computer engineering, AI, data science, and entertainment media
- Informatics
  - A distinct scientific discipline defined by a unique set of concepts, methods, knowledge base, and open challenges. (Caspersen et al., 2018)
- Computational Thinking (CT)
  - A way of solving problems, designing systems, and understanding human behavior that draws on concepts fundamental to CS... (Wing, 2006)
- Coding
  - A set of instructions that a machine can understand and execute
- Programming
  - Coding and more: debugging, organizing, applying. Part of CS and CT.

CT has promoted an informatics education

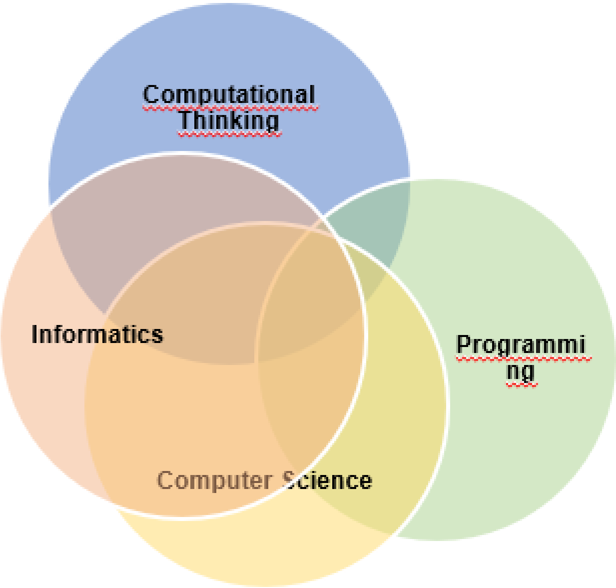


P J Denning & M Tedre. Computational Thinking. The MIT press, 2019.

CT compromises the mental skills and practices for

- ***designing*** computations that get computers to do jobs for us, and
- ***explaining*** and interpreting the world as a complex of information processes.

The definitions of CT that have emerged from the post-2006 CT movement have moved conspicuously into the public view. But many public definitions, especially as interpreted to us by policymakers, are quite narrow compared to the notions of CT developed over the earlier centuries of computing. Mainstream media occasionally give a misinformed view of the scope and influence of computing. They have led people unfamiliar with computing to make inflated claims about the power of CT that will mislead students and others into making promises about computers they cannot deliver.



The development of CT has opened Informatics Education in schools!

Why we are talking about Informatics Education

- The European Commission's *Digital Education Action Plan* (DEAP) *2021–2027* strongly emphasizes developing digital skills and competences within education and training systems.
- In 2023, the *Council of the European Union* pointed out the **urgent need to provide teachers and educators with clear guidance for the delivery of high-quality informatics education**.
- **Challenges** in Informatics Education:
  - ❖ Informatics is often limited to specific cohorts or focused on narrow topics.
  - ❖ Traditional teaching **methods** are too theoretical and boring, with little hands-on practice; this can also reinforce gender bias (electives often attract more boys than girls).
  - ❖ Schools struggle to recruit and retain qualified informatics **teachers**.
  - ❖ Lack of quality, age-appropriate teaching materials and resources.
  - ❖ Traditional **assessments** are poorly suited to evaluating informatics skills.

European Commission

EU SCIENCE HUB

The European Commission's science and knowledge service

Knowledge

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

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

European Commission

REVIEWING COMPUTATIONAL THINKING IN COMPULSORY EDUCATION

State of play and practices from computing education

Authors: Stefania Bocconi, Augusto Chioccariello, Panagiotis Kampylis, Valentina Dagienė, Patricia Wastiau, Katja Engelhardt, Jeffrey Earp, Milena Horvath, Eglė Jasutė, Chiara Malagoli, Vaida Masiulionytė-Dagienė, V., Gabriele Stupurienė.

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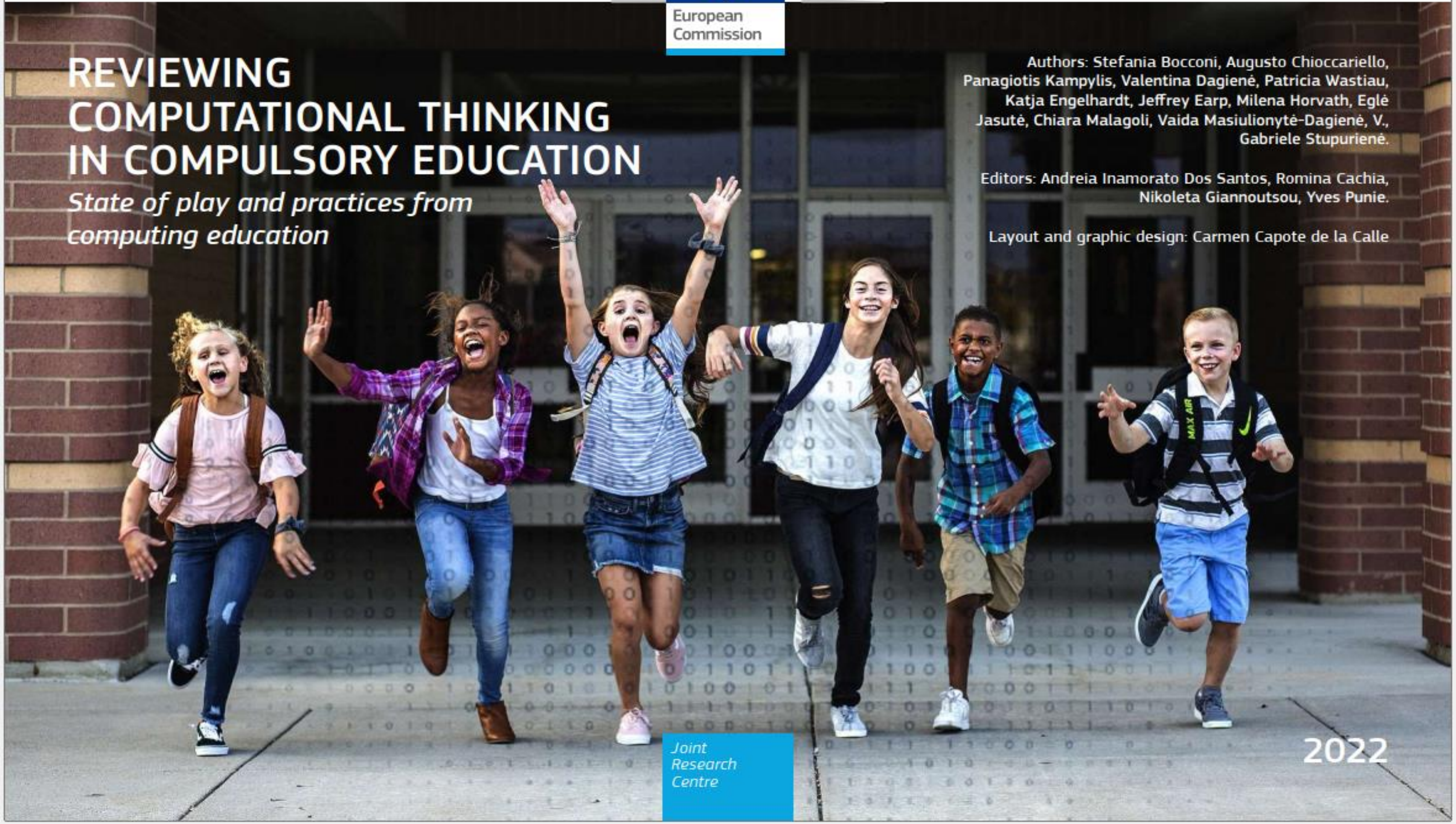


Joint Research Centre

2022

Informatics education – for strengthening **digital competence**

Digital Education Action Plan (DEAP) Action 10 emphasizes informatics education in schools as a role in equipping young people with

- a **critical and practical understanding of the digital world**

(„*A focus on inclusive high-quality computing education (informatics) at all levels of education*“, p. 15)

Digital competence aligns closely with the role of informatics education in schools.

Eurydice report highlights the development of digital competence across Europe, taught through multiple curricular approaches:

- Primary school - a cross-curricular pathway.
- Secondary school - as a separate subject—compulsory at the lower-secondary level and increasingly optional at the upper-secondary level.

Digital First

Digital Tech as the first language:
Informatics for Digital Natives

Co-funded by
the European Union

Project Digital First - Objectives

- ✓ Understanding the **theory and practice of teaching informatics** in primary and secondary schools across Europe through research and data collection
- ✓ Developing and testing **innovative pedagogical approaches to teaching informatics** with piloting in **10 countries**: Bulgaria, Croatia, Cyprus, Finland, Greece, Italy, Lithuania, Portugal, Slovenia, and Spain.
- ✓ Defining a **competencies catalogue** for informatics teachers
- ✓ Building an informatics teachers‘ support **network**
- ✓ Involving all stakeholders in shaping the future of informatics education through the project’s **dialogue clubs** to be organized in each project country.

Website: https://digitalfirstnetwork.eu/

Facebook: https://www.facebook.com/digitalfirstnetwork

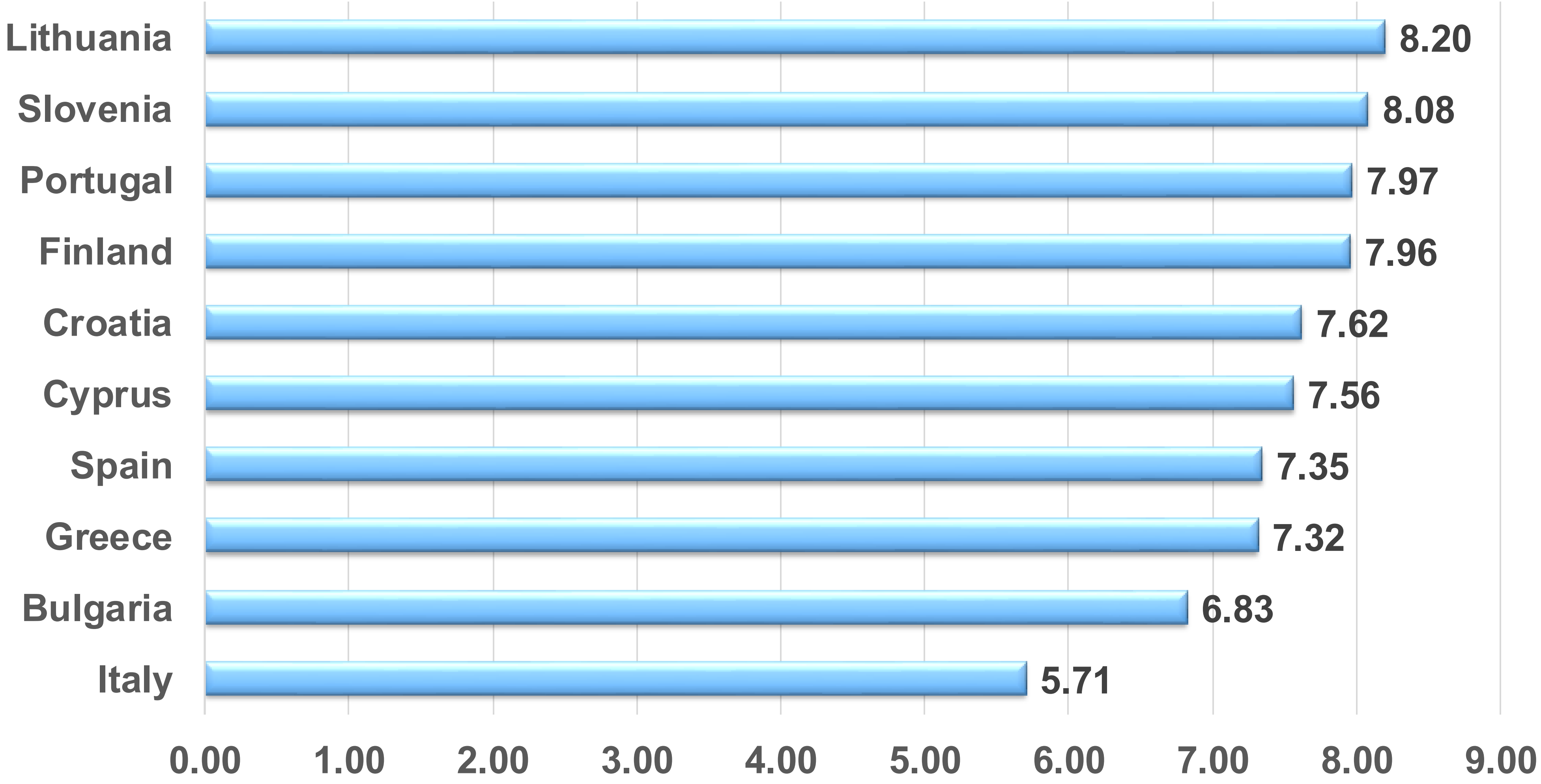
LinkedIn: https://www.linkedin.com/company/digital-first-network/posts/?feedView=all

Instagram: https://www.instagram.com/digitalfirstnetwork/

Co-funded by the European Union

How would you rate your **competence in teaching** informatics?

Scale 1 to 10



Co-funded by the European Union

Informatics Education: teaching strategies and methods

Primary school

- Teaching computing concepts and practices using unplugged activities.
- Teaching programming and coding primarily using block-based programming languages (such as Scratch, Alice, Code.org, etc.).
- Physical robots (e.g. Bee-Bots, LEGO Mindstorms).

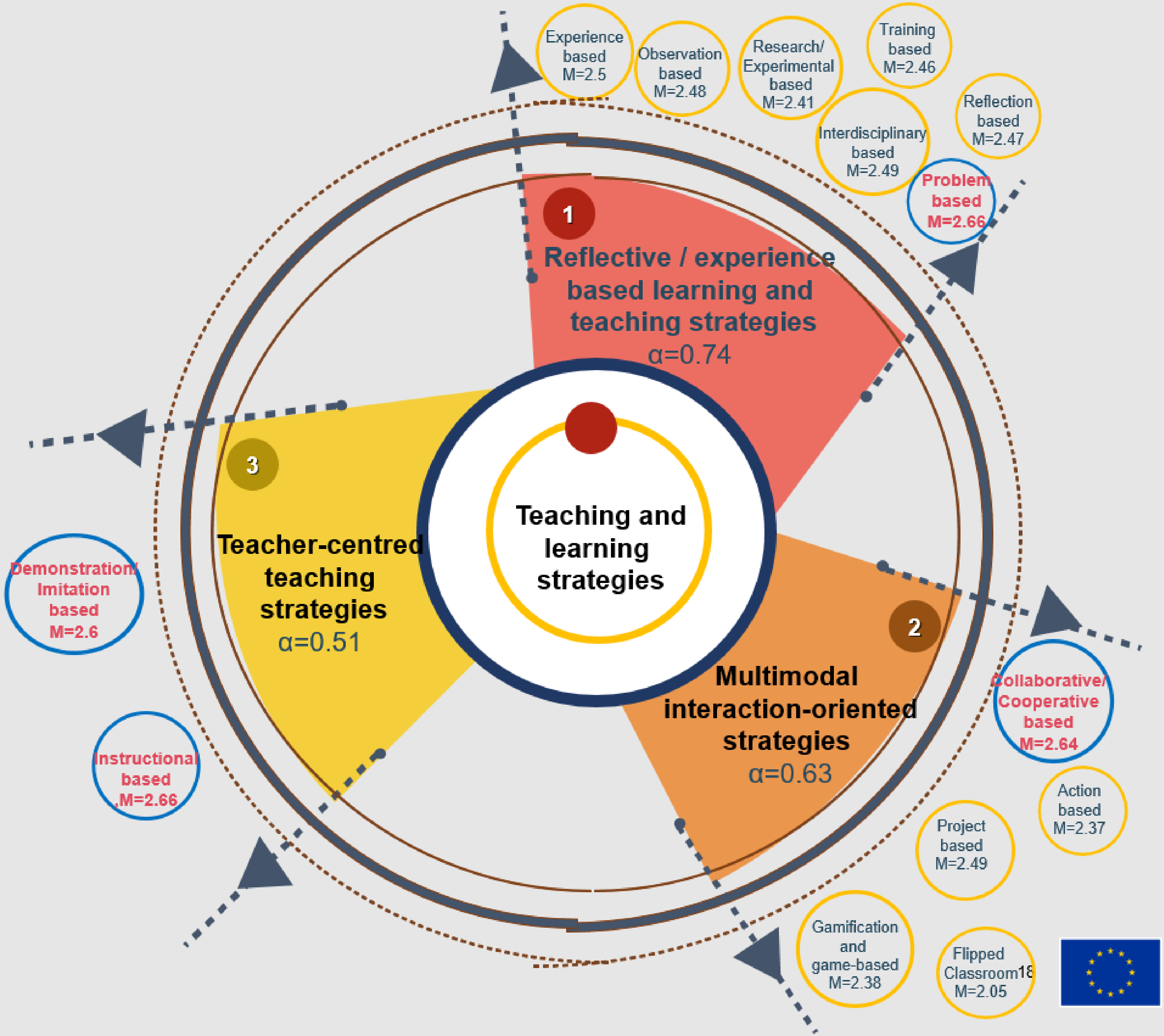
Lower-secondary education

- Informatics is recognized as a distinct discipline in 35 education systems;
- About half countries offer it as a standalone, compulsory subject for all students, typically across all grades.

Upper-secondary education

- Informatics is almost universally taught as a distinct discipline, with the vast majority of countries offering one or more informatics subjects—compulsory, optional, or both—at least in one grade.

Teaching strategies we are using in everyday practice (N=979)



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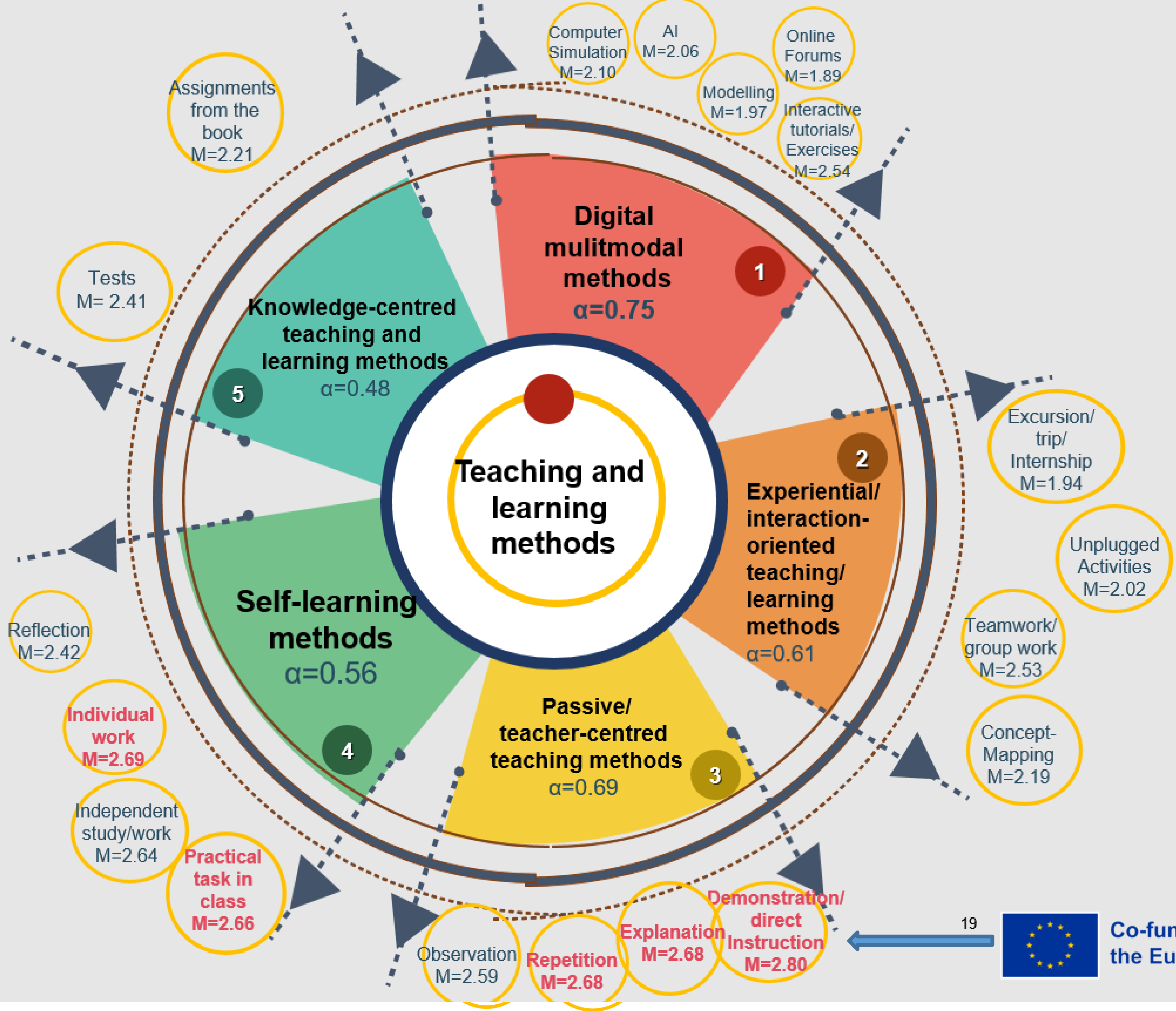
DIGITAL FIRST

Methods we use teaching informatics /CS

(N=979)



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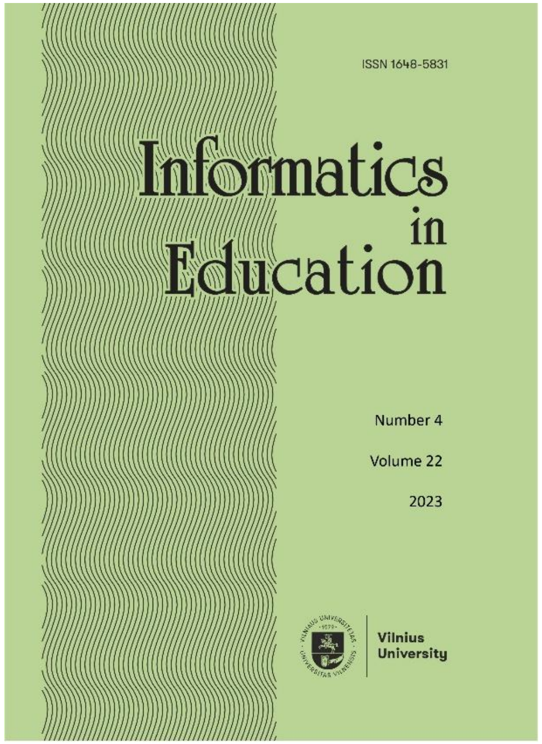
How to teach Informatics



Informatics in Education, 2025, Vol. 24, No. 1, 99–144

DOI: 10.15388/infedu.2025.05

How to Teach Problem Solving and Algorithm Design in High Schools by Constructive Induction or How to Reach True Competences in Informatics Education

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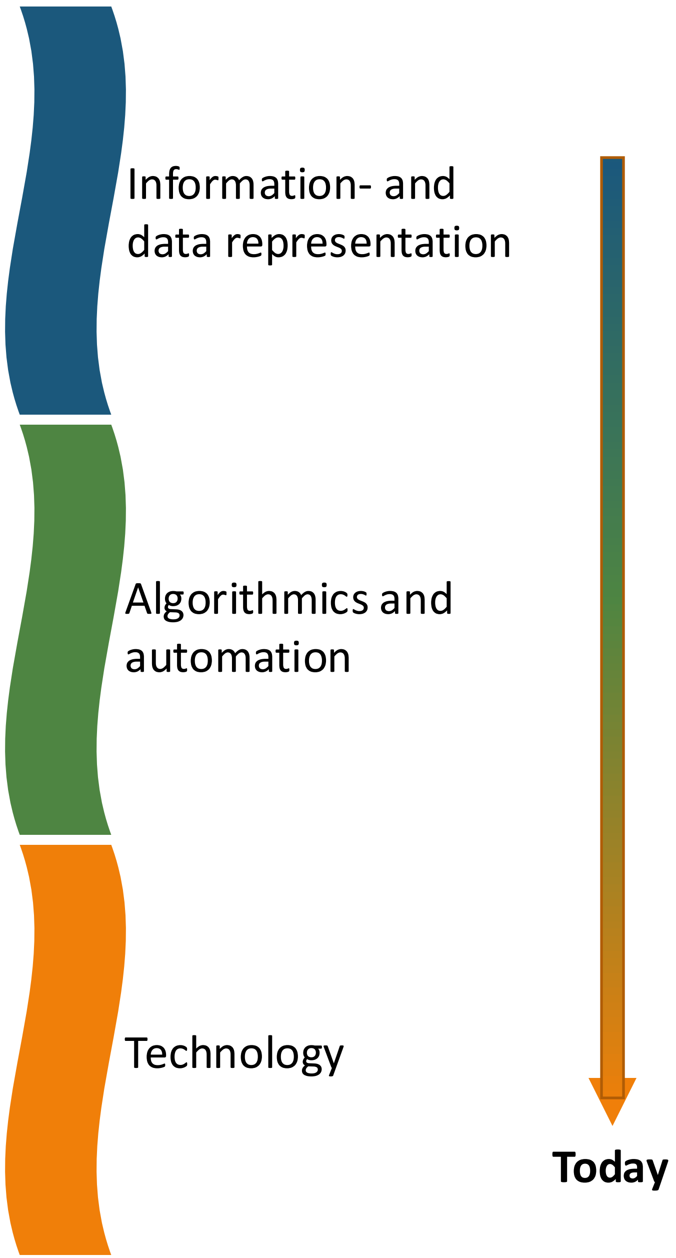
Abstract. The design of algorithms is one of the hardest topics of high school computer science. This is mainly due to the universality of algorithms as solution methods that guarantee the calculation of a correct solution for all potentially infinitely many instances of an algorithmic problem. The goal of this paper is to present a comprehensible and robust algorithms design strategy called "constructive induction" that enables high school students to discover solution methods for a large variety of algorithmic problems. The concept of constructive induction is based on searching for a universal method for solving any instance of an algorithmic problem when solutions of smaller problem instances are available.

The 3 roots of Computer Science



What is Computer Science?

> Computer science is as old as science and human civilization. It influenced the entire development of our species.

Computer science established itself as individual subject when:

1. Algorithms could be formulated well enough such that no improvisation (i.e. intellectual capability) was required for their execution
2. Technology was sufficiently developed such that the execution of algorithms could be delegated to machines

Goals of teaching informatics at school

„Let’s bring up inventors and creators of digital technologies, not only their mere consumers.“

1. Understanding, steering, and contributing to the development of the world created by humans
2. Fostering key competencies in mathematics and languages
3. Introduce **constructive thinking** (core to all technical disciplines) to general school education

“Life is not about having the right answer – or at least it should not be – it is about getting things to work.”

Seymour Papert

What We Talk About When We Talk About K-12 Computing Education

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Schulte, C., Sentance, S, … & Wu, Z. (2025). What we talk about when we talk about K-12 computing education. In *2024 Working Group Reports on Innovation and Technology in Computer Science Education* (pp. 226-257).

Table 11: Four traditions in K-12 computing education.

Tradition / **Aspect**	**Algorithmic Problem-Solving**	**Scientific**	**Design and Making**	**Societal**
View of computing as a discipline	A formal practice that focuses on algorithms, computation, and transforming information.	A method of scientific inquiry aimed at understanding the world.	An engineering science emphasizing the design and construction of artefacts within constraints.	A social practice shaped by its community, producing tools that embody and influence societal values.
Why it is important	Highlights the unique ways of thinking and problem-solving inherent to the field.	Emphasizes learning about the natural and artificial world through computational approaches.	Stresses the significance of implementing computational solutions within real-world artefacts.	Demonstrates the need to reflect on the social context and moral implications of computing.
How it shapes computing education	Encourages teaching abstract concepts and context-independent thinking.	Promotes modelling, simulation, and computational tools for inquiry.	Anchors projects in learners' creativity, interests, and collaboration to solve complex problems.	Inspires learners to examine the interplay of computing and society while fostering a sense of responsibility.

Andreas Bollin, Juraj Hromkovič, Dennis Komm, Regula Lacher

MANIFEST: Why Computer Science is a Subject in Schools

Why Computer Science must become a subject at school

1. *Understanding and shaping the world*

One of the basic purposes of school education is to enable students to understand the world they live in. Without computer science, it is impossible to understand the digital world created by humans. Worse still, it is not possible to contribute towards shaping the (digital) world without computer science knowledge and skills.

2. *Preparing for professional life*

Schools should prepare the next generation for the jobs of the future. We don't know these future jobs, but we do know that every process we can sufficiently describe will be automated, and consequently, it will be impossible to succeed in almost any profession without a basic understanding of automation processes.

3. *Strengthening economic innovation*

Each society must not limit itself to the consumption and use of digital technology. For economic success, a broad training in computer science basics is unavoidable to generate innovation and start-ups, and thus play a leading role in the development of digital technology, including AI.

4. *Computer science is the prolonged hand of mathematics*

Mathematics was developed as a powerful research instrument (there are only two – the experiment and mathematics) to investigate and shape the world. It introduces abstraction to represent the world and its phenomena in its exact formal language and then solves problems in this abstract representation. Computer science comprises abstract mathematical structures and solution methods, and develops ever more algorithms with the aim of automating the processes of knowledge generation (information generation). Computer science shapes our digital world. Curricula without computer science lessons today are like curricula without mathematics lessons at the time of the industrial revolution.

5. *Communicating the engineering mindset*

The engineering mindset understands that everything evolves and is improved continuously. Computer science starts with information representation and algorithms as solution methods and ends with functional products that provide their services in complex environments. No other subject can describe the engineering mindset as well as computer science. Schools must not be reduced to imparting knowledge. They must teach students to try things out, to design and to analyze, to evaluate and to compare the properties of their own products with others—and then to iterate in an infinite process of improvements.

Vilnius University

http://www.fsf.vu.lt/ct-math-able

Computational Thinking and Mathematical Problem Solving, an Analytics-Based Learning Environment

Co-funded by the European Union

CT&MathABLE: main work

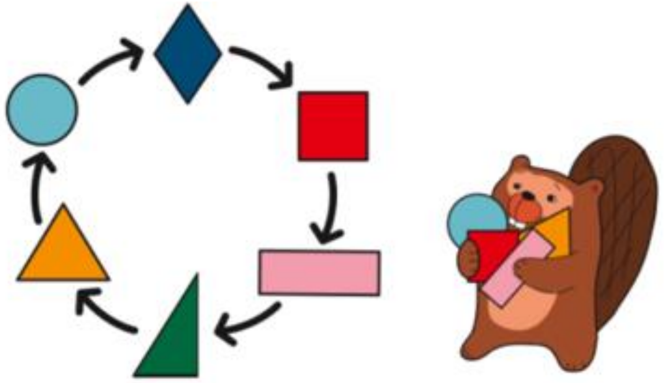
Management

- WP2: Developing **Learning Path** for CT integrated with AT
- WP3: Development of CT and AT **Assessment** Framework
- WP4: Developing **Interactive Tasks**
- WP5: Dissemination

Developing Interactive tasks

1	2	11	12	21						51	52
3	4	13	14							53	54
5	6	15	16							55	56
7	8	17	18							57	58
9	10	19	20							59	60

- Japanese calendar
- https://bebras-lodge.sp.fsf.vu.lt/public/650181e01cba4003bd1d
- Coloring
- https://bebras-lodge.sp.fsf.vu.lt/public/33d6bdc2d8c94b9ca274
- Sudoku
- https://bebras-lodge.sp.fsf.vu.lt/public/784bbfc5354d4ec1a264
- Logical reasoning
- https://bebras-lodge.sp.fsf.vu.lt/public/4d2aac149e0140af95bf



More tasks are available on the CT&MathABLE website:

https://www.fsf.vu.lt/ct-math-able#creating-a-set-of-interactive-tasks

Computational and **Algebraic** Thinking Assessment Instruments

COMATH, the CT and AT assessment instruments:

- draws on educational theories and curriculum standards from six countries
- reviewed by researchers, teacher educators, teachers, and students
- **validated** through large-scale pilot studies involving more than **6,400 students** and over **200 teachers**.

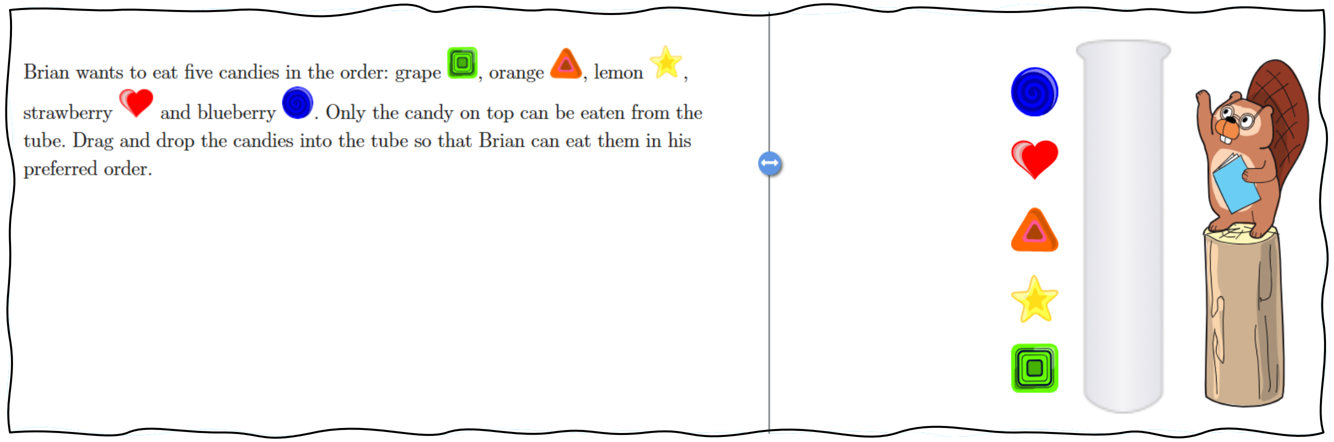
CT test focused on algorithmic thinking and other CT skills

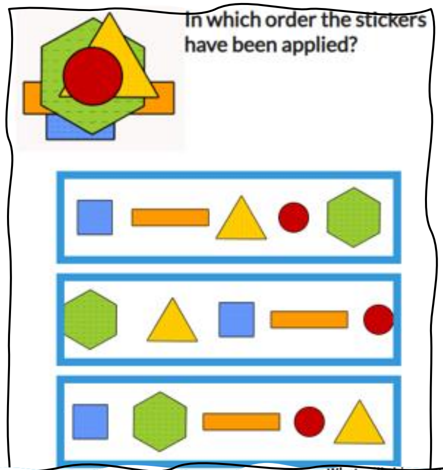
- COMATH 1-CT: 12 items
- COMATH 2-CT: 12 items
- COMATH 3-CT: 14 items

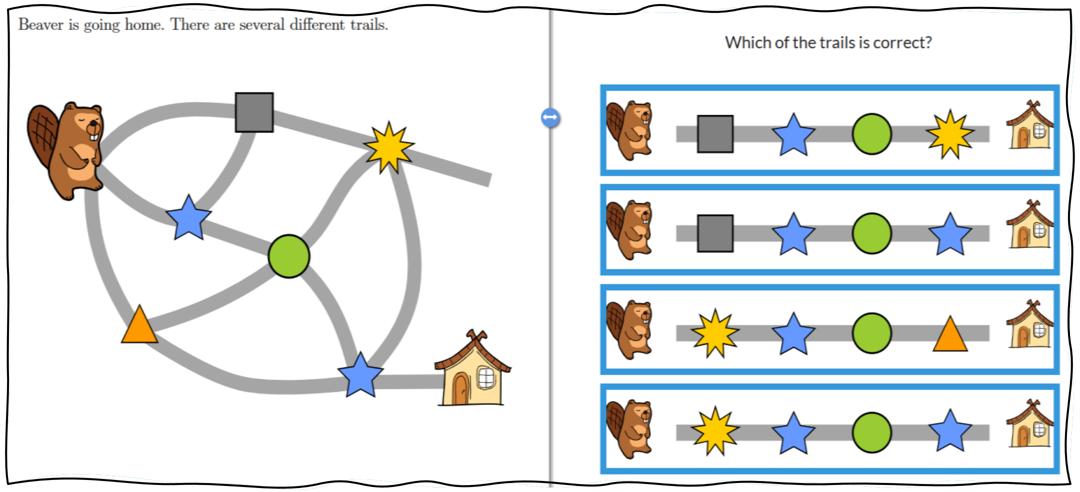
Assessment instruments are available on the CT&MathABLE website

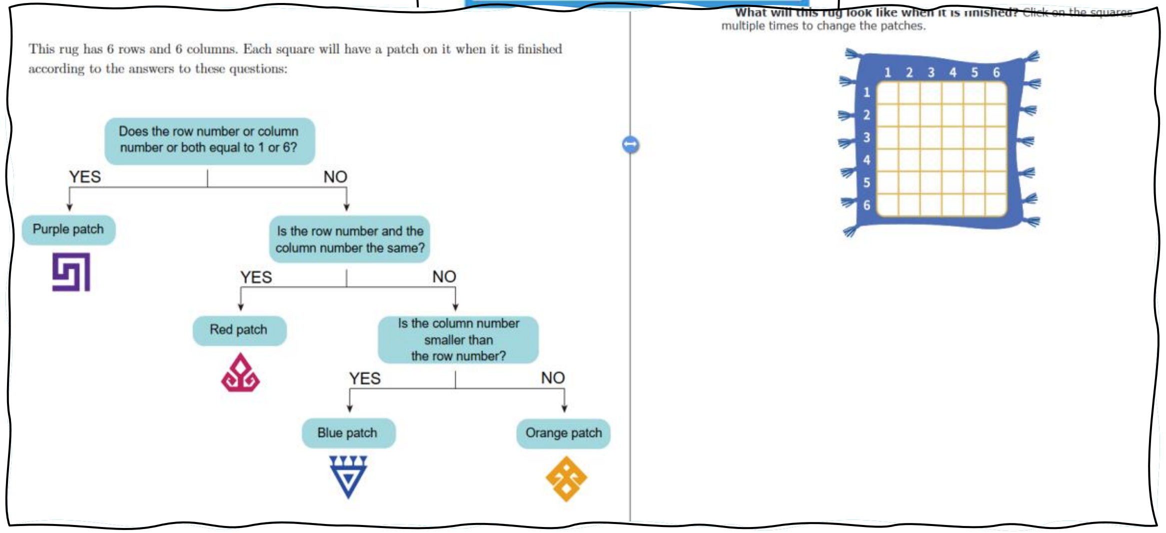
https://www.fsf.vu.lt/ct-math-able#assessment-instruments-for-ct-and-at

Computational Thinking Assessment Instruments: examples



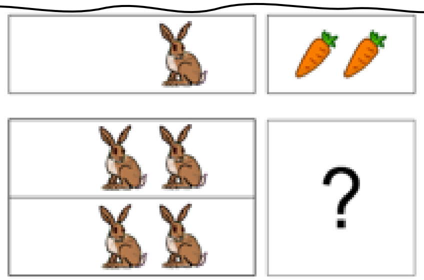






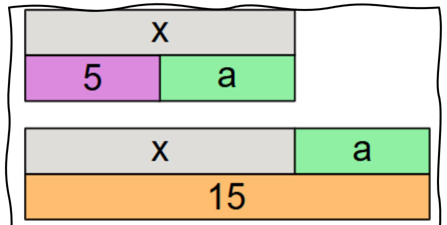
Assessment instruments are available on the CT&MathABLE website
https://www.fsf.vu.lt/ct-math-able#assessment-instruments-for-ct-and-at

Algebraic Thinking Assessment Instruments: examples



You need **2 carrots** each day to feed **a rabbit**.

How many carrots would you need to feed **2 rabbits** for **2 days**?

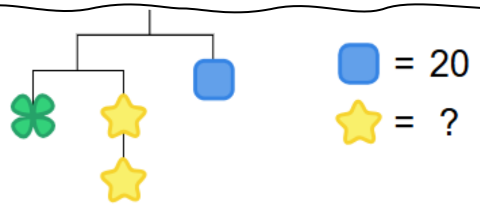


How long is block x?

The same shape stands for the same number.

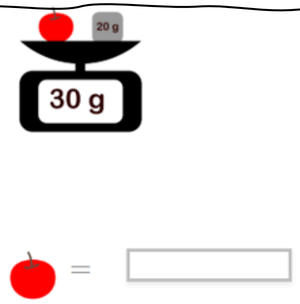
If ● + ★ = 7,

then ● + ★ + 3 = ...



The mobile is balanced.

What is the weight (mass) of one star ?



m is any number.

Which one is larger?

a) m

b) m + 2

c) Could be either

Assessment instruments are available on the CT&MathABLE website

https://www.fsf.vu.lt/ct-math-able#assessment-instruments-for-ct-and-at

Informatics Matura Exam

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The Influence of Social Conditionality on the Results in Computer Science Test of Graduates

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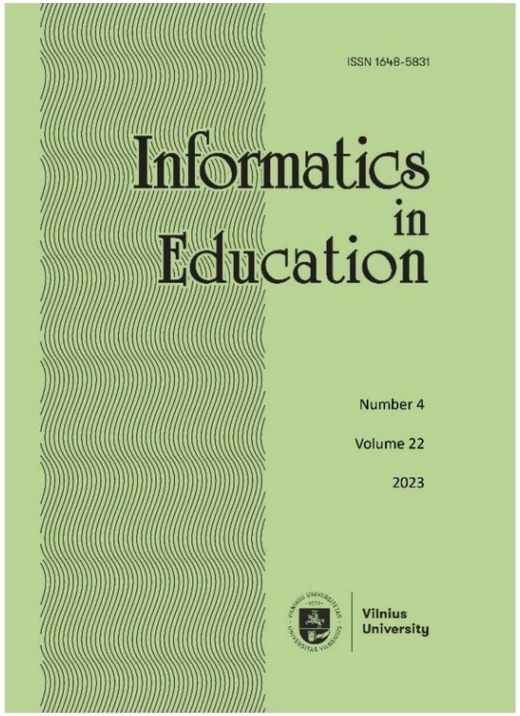
Received: June 2024

Abstract. The paper presents graduates results in computer science testing according to their dependence from students' gender, family socioeconomic status, and the type of prosperity of the locality of the school in Lithuania. It was found that the gender of the graduate does not affect the results in computer science test. However, the girls who chooses to take the Computer Science Matura Exam make up only 1/5 of all graduates. Meanwhile, the socioeconomic status of the stu-



Merkys, G., Vaitkevičius, S., Bubelienė, D., & Brazdeikis, V. (2025). The Influence of Social Conditionality on the Results in Computer Science Test of Graduates. *Informatics in Education*, *24*(1), 145-173. https://www.infedu.vu.lt/journal/INFEDU/article/800/info

Informatics Education: Curricula

Eurydice Report (2022): Informatics Education in Europe

- **Primary education** – very diverse: from compulsory subjects starting in Grade 1 to optional or integrated later, despite research recommending an early start.
- **Lower-secondary education** – most systems combine **mandatory + optional** approaches; nearly all require some form of informatics.
- **Upper-secondary education** – usually **optional**, or compulsory only for specific student groups, taught as a dedicated subject.

Eurydice Report (2023): Digital Competence at School

•Identifies 3 key curriculum indicators:

• **Grade level** for starting mandatory digital competence

• **Curricular approaches** (cross-curricular, integrated, or separate)

• **Informatics as a separate subject**

Beyond Europe – USA

•CS education in K–12 is expanding rapidly

•No single national authority → state-level variation

•CT embedded in widely adopted standards

•2023 report:

57.5% of high schools offer foundational CS

5.8% of students enrolled (across 35 states)

Curricula

Informatics in Education, 2021, Vol. 20, No. 3, 333–360 333

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Designing Informatics Curriculum for K-12 Education: From Concepts to Implementations

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Received: May 2021

Abstract. Computing as a discipline has common roots with mathematics and written languages, and computing as a way of thinking and handling has been integral to human culture since ever. This is not only a reasonable argument for convincing society to consider informatics as one of the very fundamental pillars of education, but it also puts the potential contributions of teaching informatics in schools into the correct perspective in the context of science and humanities. Many European countries are switching from teaching information technologies to informatics education during the current second decade of this century. Informatics curriculum is becoming a central part of school education.

We explain and design a way of developing informatics curriculum that offer the critical competences new generations need to survive and thrive in todays' knowledge society and will allow them to contribute to the future development of society. These competences also strongly support the development of their intellectual potential and creativity. Our design of informatics curriculum takes into account the interaction with other scientific disciplines as well with the subject didactics, pedagogy and psychology.

6.1.1. *Programming*

1. **Executing programs as sequences of instructions (BT 1-3, Age 4+)**

   One starts with a very poor programming language consisting of a few instructions only (in the beginning represented by a symbol and later by one word) and the goal is to correctly interpret a given program, i.e., to take the role of a robot and to execute few commands. The usual starting point is a movement in two-dimensional space. For young children this strengthens their ability of orientation in space and planning with respect to time.

2. **Developing (writing) programs without inputs as sequence of unstructured instructions (BT 2-3, Age 4+)**

   A program without input (parameter) describes exactly one activity. The goal is to transform a description of an activity (for instance a trajectory in a landscape) to a program as another description of this trajectory. A classic example is writing programs to draw simple pictures.

3. **Searching for logical errors if a program does not execute the expected activity (BT 4, Age 6+)**

   We are still working with programs consisting of sequences of unstructured instructions. To train pupils to find and correct logical errors in own programs as well as in given programs is as important as to learn to write programs. Programming skills cannot be mastered without this competence. To support the training of pupils in achieving this competence one has to offer a programming environment in which the pupils can execute programs slowly and move forward as well as backward in the execution, while observing the effect of particular instructions of the program.

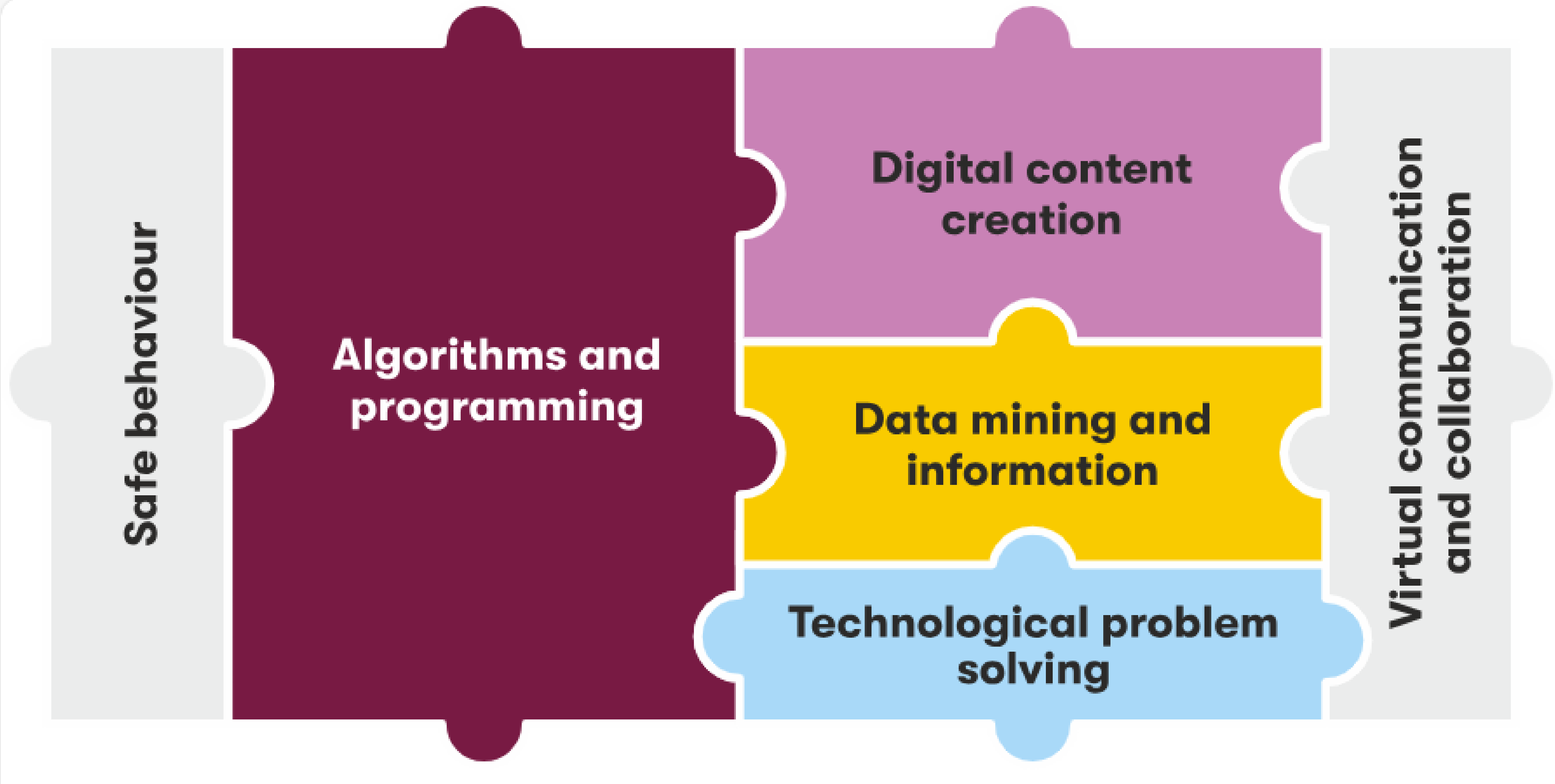
4. **Using loops without parameters (BT 2-4, Age 7+)**

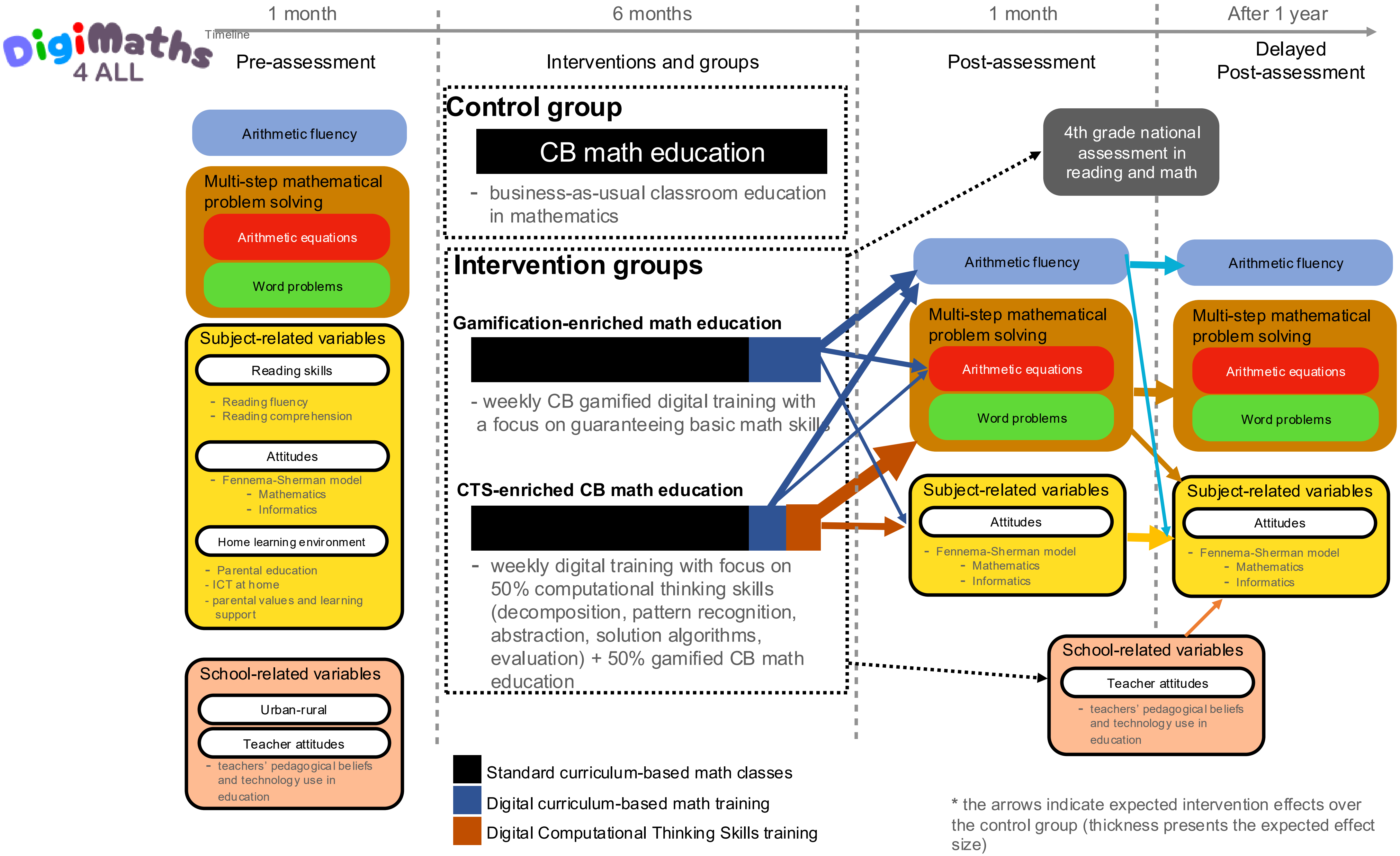
   First pupils recognize repetition of patterns in programs and can shorten the program description by applying repeat-loop. Secondly pupils recognize possible repetitions in task descriptions (drawing pictures, running a regular trajectory) and design programs with loops.

5. **Understanding and applying modular design (BT 2-4, 6, Age 10+)**

   Pupils learn to partition a task into a couple of subtasks, develop and check the correct functionality of the programs for the subtask they are working on, and to

Informatics curriculum in Lithuania





DigiMaths 4 ALL
Timeline
1 month
6 months
1 month
After 1 year
Pre-assessment
Interventions and groups
Post-assessment
Delayed Post-assessment
Arithmetic fluency
Multi-step mathematical problem solving
Arithmetic equations
Word problems
Subject-related variables
Reading skills
- Reading fluency
- Reading comprehension
Attitudes
- Fennema-Sherman model
- Mathematics
- Informatics
Home learning environment
- Parental education
- ICT at home
- parental values and learning support
School-related variables
Urban-rural
Teacher attitudes
- teachers' pedagogical beliefs and technology use in education
Control group
CB math education
- business-as-usual classroom education in mathematics
Intervention groups
Gamification-enriched math education
- weekly CB gamified digital training with a focus on guaranteeing basic math skills
CTS-enriched CB math education
- weekly digital training with focus on 50% computational thinking skills (decomposition, pattern recognition, abstraction, solution algorithms, evaluation) + 50% gamified CB math education
4th grade national assessment in reading and math
Arithmetic fluency
Multi-step mathematical problem solving
Arithmetic equations
Word problems
Subject-related variables
Attitudes
- Fennema-Sherman model
- Mathematics
- Informatics
Arithmetic fluency
Multi-step mathematical problem solving
Arithmetic equations
Word problems
Subject-related variables
Attitudes
- Fennema-Sherman model
- Mathematics
- Informatics
School-related variables
Teacher attitudes
- teachers' pedagogical beliefs and technology use in education
Standard curriculum-based math classes
Digital curriculum-based math training
Digital Computational Thinking Skills training
* the arrows indicate expected intervention effects over the control group (thickness presents the expected effect size)

CT in Practice: Synergies for Learning with AI

AISynergies

NPHZ-2025/10117, 08/2025 - 08/2027

A group of researchers and educators from the Nordic and Baltic countries

An annual meeting takes place in the last week of August in Druskininkai, Lithuania

2026: August 22-29
Welcome!

Join us!

Informatics Education and Artificial Intelligence

AI constitutes a broad domain within Informatics: elements of logic & reasoning, learning & perception, modelling, security, and ethics.

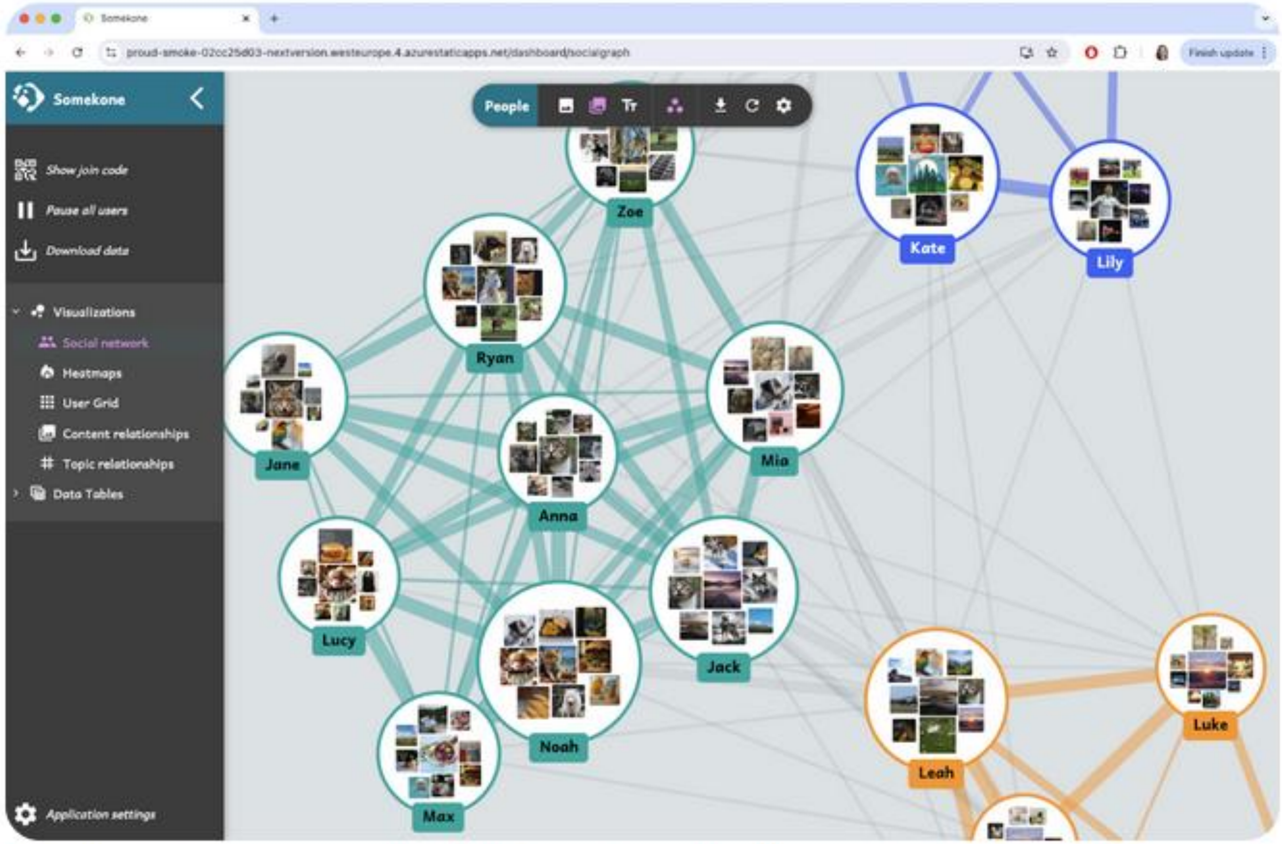
AI competencies could be structured into three areas:

1. Teaching **for AI**, which develops critical engagement skills for an AI-shaped world.
2. Teaching **with AI**, which focuses on pedagogically sound implementation of AI systems and understanding their technical foundations.
3. Teaching **about AI**, which covers fundamental AI concepts and literacy adapted to student age levels, preparing them for future careers regardless of specialization.

Generation AI

Somekone: The team have developed an educational tool for classroom use, based on explainable AI (XAI), designed to demystify key social media mechanisms—tracking, profiling, and content recommendation—for novice learners. The tool provides a familiar, interactive interface that resonates with learners' experiences with popular social media platforms, while offering them the opportunity to see what is happening 'under the hood', exposing basic mechanisms of datafication. Learners gain first-hand experience of how even the slightest actions, such as pausing to view content, are captured and recorded in their digital footprint, and further distilled into a personal profile. The tool is used in an intervention that encourages young people to discuss ethical issues around bias and privacy.

Social Machine - Somekone



Somekone: the system reveals links between social media participants based on images liked

https://www.generation-ai-stn.fi/en/

How AI is revolutionizing education 4.0

WORLD ECONOMIC FORUM

Reports

Published: 28 April 2024

Shaping the Future of Learning: The Role of AI in Education 4.0

Download PDF

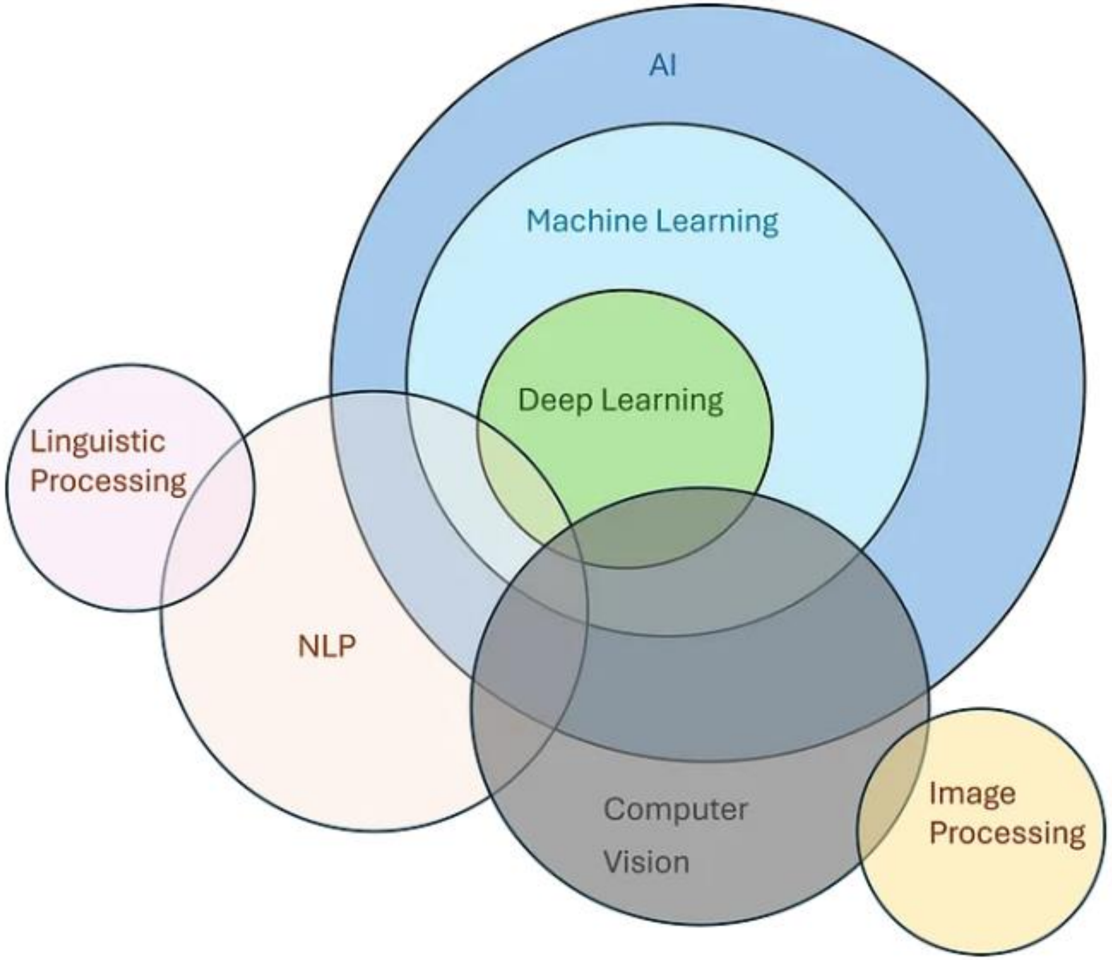
This report explores the potential for artificial intelligence to benefit educators, students and teachers. Case studies show how AI can personalize learning experiences, streamline administrative tasks, and integrate into curricula.

https://www.weforum.org/publications/shaping-the-future-of-learning-the-role-of-ai-in-education-4-0/

Four key promises that have emerged for AI to enable Education 4.0

1. Supporting teachers' roles through augmentation and automation
2. Refining assessment and analytics in education
3. Supporting AI and digital literacy
4. Personalizing learning content and experience

CT and AI

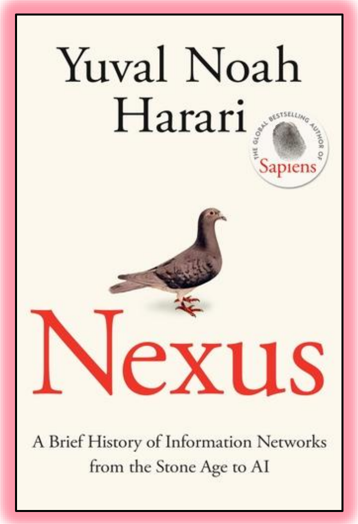


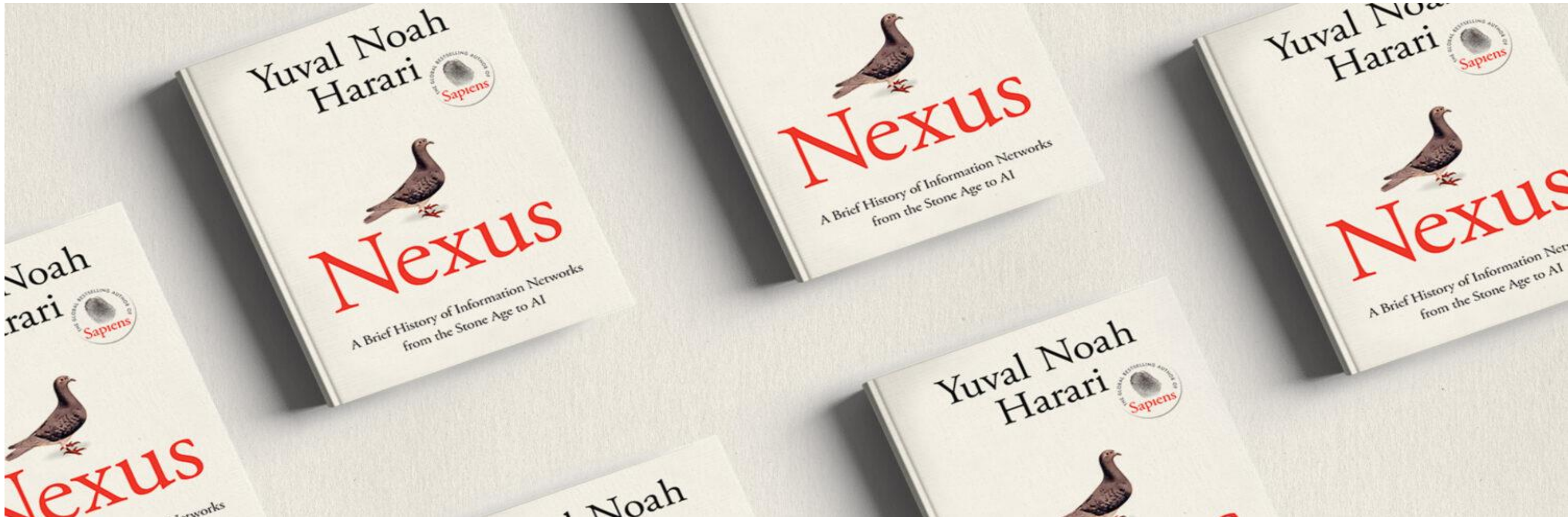
CT is about **improving the problem solving** capability of humans by leveraging the way a computer "thinks" when it solves problems.

Navigating the opportunities and risks of AI in education

Yuval Noah Harari returns with a major new book that explores humanity's voyage into the Information Age – *Nexus: A Brief History of Information Networks from the Stone Age to AI*

He provides an essential background to understanding the threats and promises of today's AI revolution





Nexus

Harari addresses the urgent choices we face today, as non-human intelligence threatens our very existence.

In the 21st century, AI may form the nexus for a new network of delusions that could prevent future generations from even attempting to expose its lies and fictions.

However, history is not deterministic, and neither is technology: **by making informed choices, we can still prevent the worst outcomes**.

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Thank you

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