INFORMATICS EUROPE

Informatics for All

A European perspective

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Albert Einstein on school education (1931)

- Primary goal
- … a **balanced** development of an individual
- … a general ability **to think independently and to evaluate critically**

- … will find their way in life and will be able **to adapt to progress and changes**

Why teaching informatics in schools?

- Why going to school?

- To prepare citizens for the society
- … which includes to be able to find a job

- Well-informed citizens able to understand and decide

- Universal education is the corner stone of democracy

- Learning informatics in schools is needed to prepare well-informed digital citizens (e.g., data, privacy, AI, …)

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Isn't *Digital Education* enough?

- **Digital** is an "umbrella" terms covering all the modern technologies based on computers
- Think to it like an evolution of "industrial"

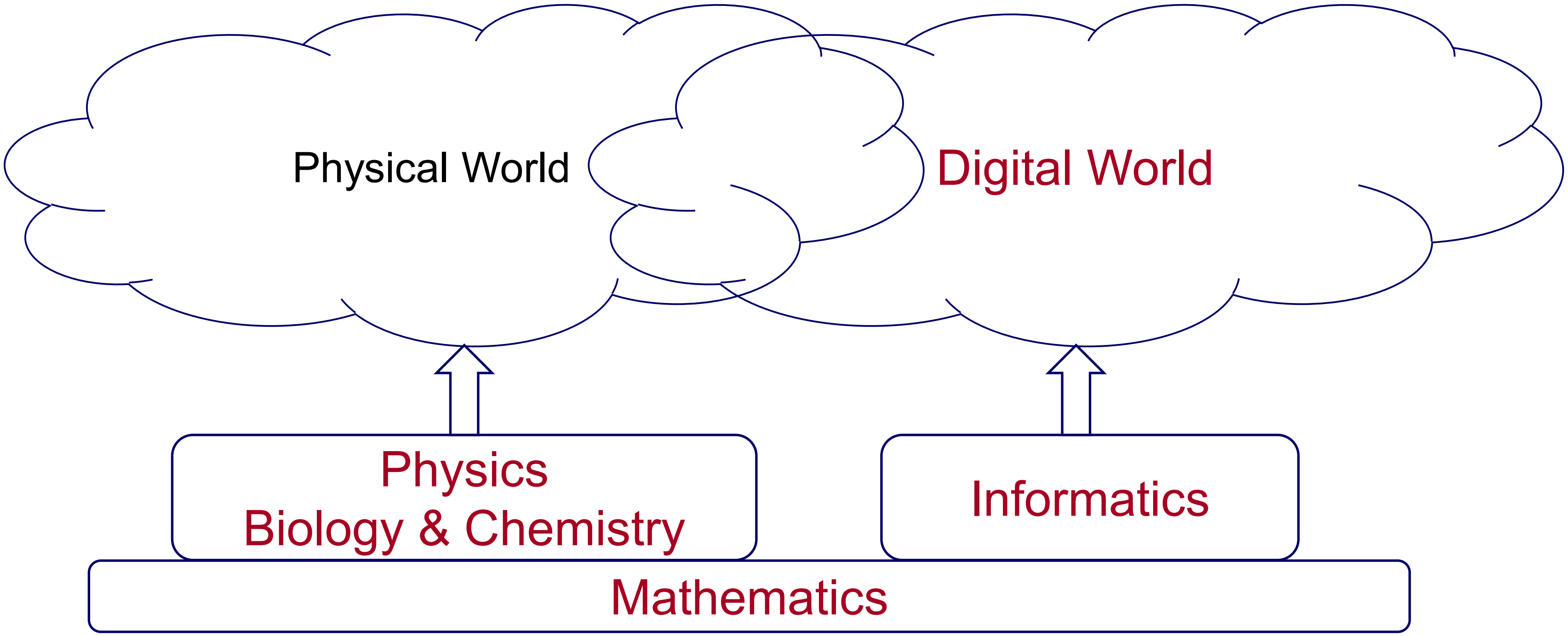
"Industrial revolution" ⟹ "Digital revolution"

"Society of machines" ⟹ "Society of digital machines"

- To prepare citizens for the *industrial society* we introduced scientific and technological education in all schools: Physics, Chemistry, Biology, …
- We have now to introduce in all schools the science and technology behind the *digital society* : **Informatics**

What's in a name?

- **Informatics** is the largest common root of the various names in Europe of the discipline known in many parts of the world as "Computer Science" or "Computing"



But Informatics is not a science, it's just another technology… ?!?

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Which objects does Informatics study?

- **information processes**:
- **automated processing of representations**

also called "computation"

- Automated, i.e. mechanical, like a clock
- Representations, i.e. signs without an intrinsic meaning
- Processing, i.e. the dynamics of the executing agent

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Beware of language issues (1)

- **Informatics is not (just) "coding"**, as Mathematics is not (just) "table of Pythagoras"

- Multiplication is (just a) part of Arithmetic
- Arithmetic is (just a) part of Mathematics (Geometry, Algebra, Probability, Statistics, Analysis, …)

- Coding (or programming) is (just a) part of the software development process
  - Analysis – Design – Coding (Programming) – Testing – Debugging
- Software is (just a) part of Informatics (Data Representation, Algorithms, Programming Languages, Computing Systems, Distributed Computing, Human-Computer Interaction, …)

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Beware of language issues (2)

- **What about "computational thinking" ?**
- It's the habit of thinking developed by doing Informatics, like "mathematical thinking" is habit of thinking of Mathematicians

- Physicist: masses, forces, fields, …
- Biologist: cell, organism, metabolism, …
- Mathematician: quantity, relation, structure, …
- Informatician: automaton, algorithm, program…

- Would one teach "mathematical thinking" or "biological thinking" in schools?

Why speaking about "computational thinking" ?

An instrument to explain in brief why computer science is a novel and independent scientific discipline and to denote its "conceptual kernel"

E.Nardelli, *Do we really need computational thinking?*, Comm. ACM, accepted for publication, 2018

- How to explain what the "conceptual kernel" is and why informatics is a novel scientific discipline?

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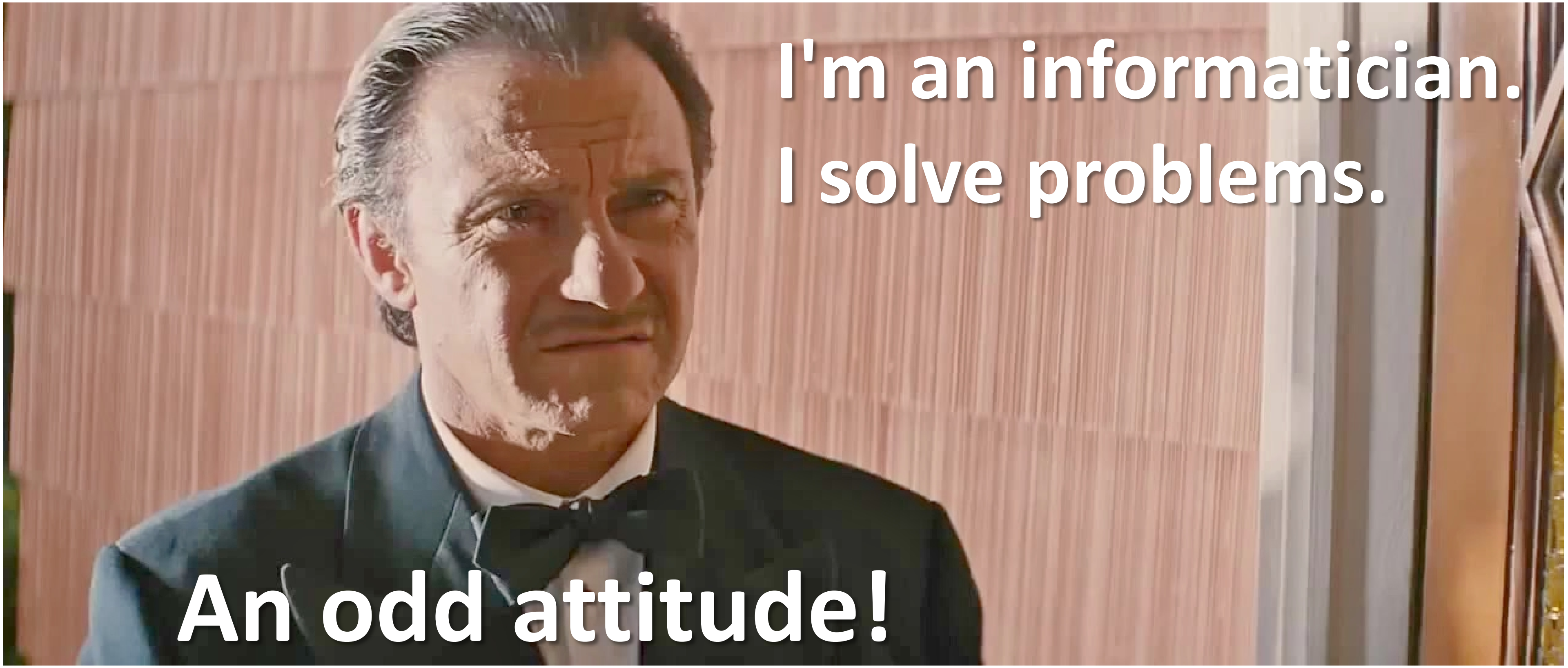
A big misunderstanding…

… computational thinking is a **mental process to solve problems** by following specific methods and tools



Solving problems?

- A *mathematical* solution to a problem is

  a formula defining the answer

- An *informatics* solution to a problem is

  a process computing the answer

- **Process**: an **algorithm** implemented in a **language** executed by an **automaton**

The conceptual kernel of informatics

FROM

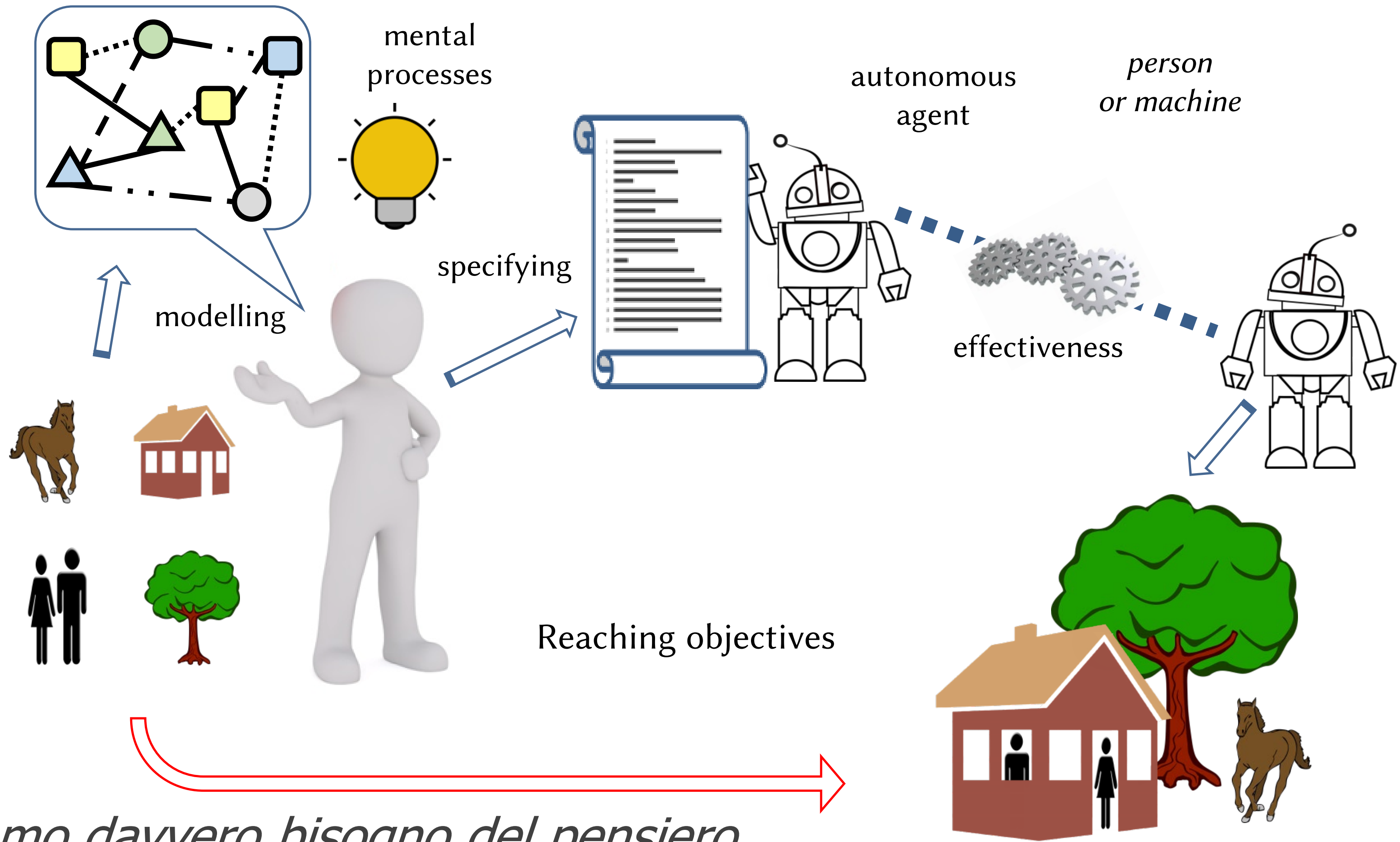
Solving problems

TO

Having problems solved

- "*A difference which makes a difference* " (G.Bateson)
- Without the **effective** processing agent (i.e., the automaton) there is no informatics

From solving problems to having problems solved



Abbiamo davvero bisogno del pensiero computazionale?, Mondo Digitale, Nov.2017

Computational thinking definitions

- WING 2011: «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», *clarifying then in 2014* «… that a computer - human or machine - can effectively carry out»
- AHO 2011: «the thought processes involved in formulating problems so their solutions can be represented as computational steps and algorithms. An important part of this process is finding appropriate models of computation with which to formulate the problem and derive its solutions» *clarifying that* «models of computation whose semantics is clear and whose behaviors and capabilities are well understood»
- My comment: we do not have a computation model for human beings…

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PISA 2021 framework for Maths test (+)

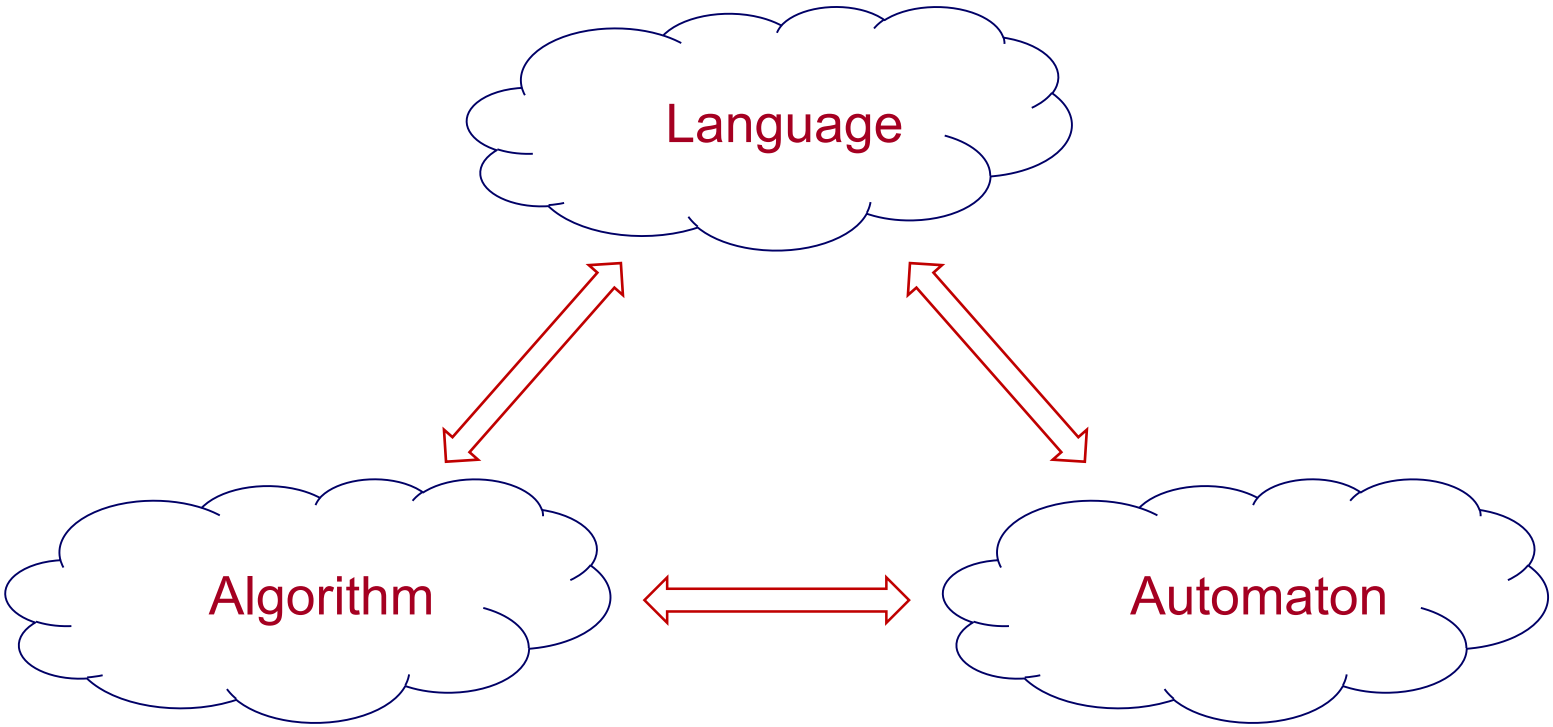
- … mathematical literacy in the 21st century **includes** mathematical reasoning and **some aspects of computational thinking**.
- … students should possess and be able to **demonstrate computational thinking skills** as they apply to mathematics as part of their problem-solving practice.
- In order for students to be mathematically literate they must … **be able to demonstrate computational thinking skills** as part of their problem-solving practice
- The **combination of mathematical and computational thinking not only becomes essential** to effectively support the development of students' conceptual understanding of the mathematical domain, but also to develop their computational thinking concepts and skills…

PISA 2021 framework for Maths test (-)

- A set of constituent practices positioned under the computational thinking umbrella (namely abstraction, algorithmic thinking, automation, decomposition and generalisation) **are also central to both mathematical reasoning and problem solving processes**.
- The nature of computational thinking within mathematics is conceptualised as defining and elaborating mathematical knowledge that can be **expressed by programming**, allowing students to dynamically model mathematical concepts and relationships.
- Aspects of computational thinking form a **rapidly evolving and growing dimension of both mathematics and mathematical literacy**. The PISA 2021 mathematical literacy framework illustrates how computational thinking is **both part of doing mathematics and impacting on doing mathematics**.

The scientific "ingredients"

(for a centralized computation, distributed ones require more)



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The great power of informatics

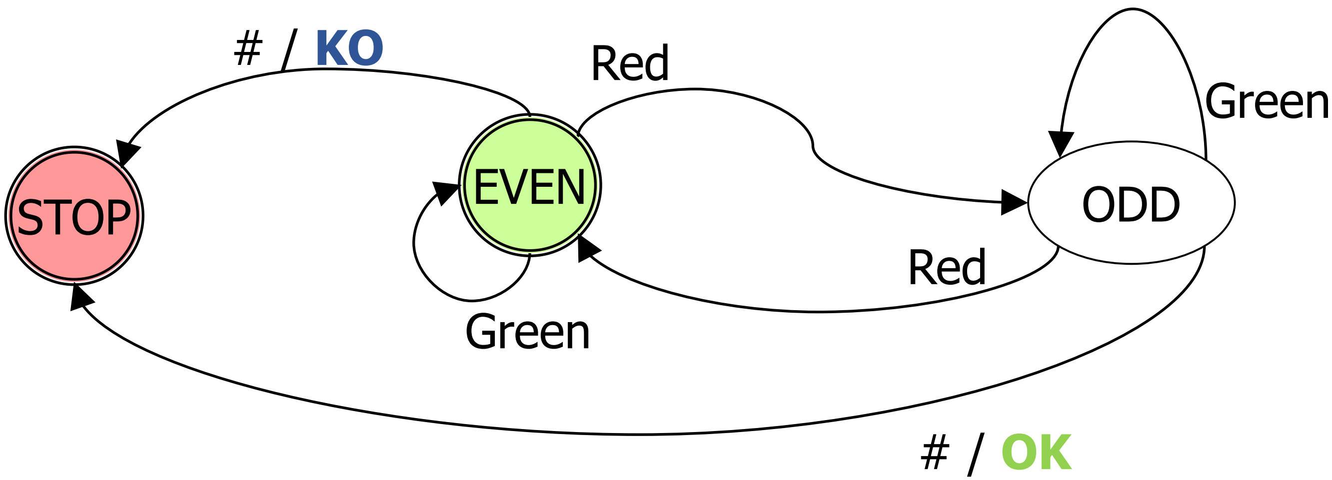
- The agent executes instructions
  whose **meaning is unknown**
  to manipulate representations (i.e. data)
  whose **meaning is unknown**

- "Automaton" is the technical term for agent

- Go very slowly with the computing power of automata used in school to study informatics
- Work as much as possible with un-plugged automata

Automaton to compute parity

- Determine whether a sequence of "Red" and "Green" ended by "#" contains an odd number of "Red"
- Starts in EVEN and terminates when arrives in STOP



The "representation" of automaton

- Working rules:
  1. look for row corresponding to "current status" and "input";
  2. move to the "new state" and write "output"

Current status	Input	Output	New Status
Even	Red	-	Odd
Even	Green	-	Even
Even	#	KO	Stop
Odd	Red	-	Even
Odd	Green	-	Odd
Odd	#	OK	Stop

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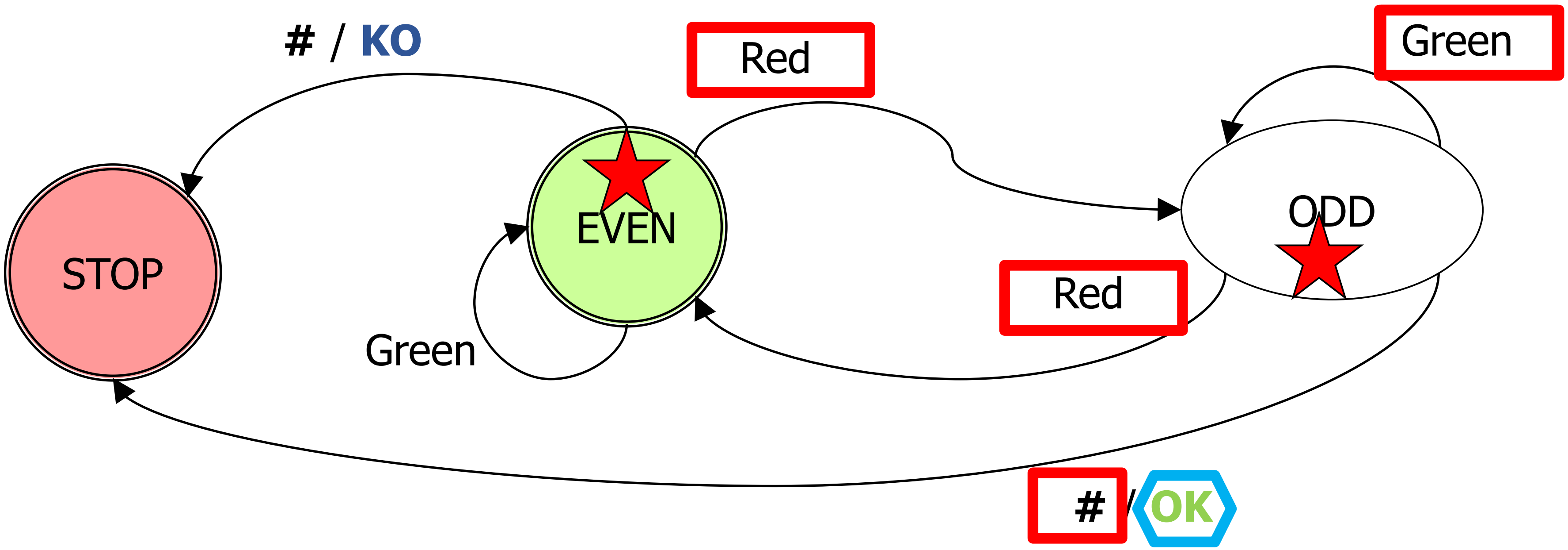
Automaton to compute parity

Red, | Green, | Red, | Red, | Green, | #



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A different problem

- Determine whether a sequence of "Red" and "Green" ended by "#" contains:
  - a sequence of *N* consecutive "Red" and then
  - a sequence of *N* consecutive "Green",
  - where *N* is not known in advance.

- Requires a different and more powerful automaton
- Pushdown Automaton
- Reflection on automata and their capabilities is fundamental for students to understand what informatics is about (in Informatics Education Research they use the term "Notional Machine")

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The great power of informatics

- The agent executes instructions
  whose **meaning is unknown**
  to manipulate representations (i.e. data)
  whose **meaning is unknown**

- But "instructions" are representations themselves…
- …and can be manipulated

- SELF-LOOP: representations manipulating representations

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A replicating program (1)

Print the value of P

def. A	P = ₪;		(*assignment*)	
prog.1	P = ₪;	print P;	⇒	₪
prog.2	P = ₪;	print "P";	⇒	P
prog.3	P = ₪;	print "P =" P;	⇒	P = ₪

def. B 3|₪; stands for ₪; ₪; ₪; (*a shortcut*)

prog.4	P = 3|₪;	print P;	⇒	₪; ₪; ₪;
prog.5	P = 3|₪;	print "P";	⇒	P
prog.6	P = 3|₪;	print "P =" P;	⇒	P = ₪; ₪; ₪;

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A replicating program (2)

P=2|print "P=2|" P; print "P=2|" P;

The value of P

print "P=2|" P; print "P=2|" P;

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Informatics: the 3rd "power" revolution

http://www.broadband4europe.com/informatics-third-power-revolution-consequences-part-1/

- 1st "power" revolution (1400): **invention of the printing press**

- … 800 million books after …
- 2nd "power" revolution (1700): **industrial revolution**

- … 800 billion machines after …
- 3rd "power" revolution (1900): **informatics revolution**

Informatics: the 3rd "power" revolution (cont.)

- 1st "power" revolution (1400): **invention of the printing press**
- Replicability of knowledge: *books*
- Overcomes time and space constraints to learn
- Breaks the power of authority ("ipse dixit")

- … 800 million *books* after …
- 2nd "power" revolution (1700): **industrial revolution**
- Replicability of physical strength: *machines*
- Boost physical capabilities of humankind
- Breaks the power of the nature

- … 800 billion *machines* after …
- 3rd "power" revolution (1900): **informatics revolution**
- Replicability of *actionable* knowledge ("*ready to be put in action*")
- Amplifies cognitive capabilities of humankind
- Breaks the power of human intelligence

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Informatics revolution: the consequences

- We cannot envision them...

- "Digital machines" are substituting people in many tasks
- But without the flexibility and adaptability of human beings

- People will still be needed…
- …but will have to be properly educated in the science behind these machines

- How can we do it?
- **Informatics for All**

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Informatics for All
The strategy

ACM Europe & Informatics Europe

February 2018

Downloadable from
http://informaticsforall.org

- **All students** must have access to ongoing education in Informatics in the school system and Informatics teaching should start in **primary school**
- Informatics curricula should reflect the scientific and constructive nature of the discipline, and be seen as **fundamental to twenty-first century education** by all stakeholders (including educators, pupils and their parents)
- Informatics courses must be **compulsory** and recognized by each country's educational system as being at least **on a par with courses in STEM**

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big trends

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BY MICHAEL E. CASPERSEN, JUDITH GAL-EZER, ANDREW MCGETTRICK, AND ENRICO NARDELLI

Informatics as a Fundamental Discipline for the 21st Century

INFORMATICS FOR ALL is a coalition whose aim is to establish informatics as a fundamental discipline to be taken by all students in school. Informatics should be seen as important as mathematics, the sciences, and the various languages. It should be recognized by all as a truly foundational discipline that plays a significant role in education for the 21st century.

The European scene. In Europe, education is a matter left to the individual states. However, education, competencies, and preparedness of the workforce are all important matters for the European Union (EU).

Importantly, there is a recognition that the education systems of Europe do not collectively prepare students sufficiently well for the challenges of the digital economy. These systems need to be fundamentally transformed and modernized. In January 2018, a Digital Education Action Plan,[1] which set out a number of priorities, was published by the EU. The most relevant priority for our initiative is "Developing relevant digital competences and skills for the digital transformation," and the Plan suggests one way to implement this is to "Bring coding classes to all schools in Europe." This is important, but more is needed, as we will explain in this article.

ACM Europe and Informatics Europe. ACM Europe (europe.acm.org) was established in 2008, and Informatics Europe (www.informatics-europe.org) in 2006. From the early days, the two organizations have collaborated on educational matters; through this liaison, they are seen to project to the wider community a single message about aspects of informatics[a] education. In 2013, the two groups set up and funded a Committee on European Computing Education (CECE) to undertake a study that would capture the state of informatics education across the administrative units of Europe (generally, these units are the countries, but within Germany, for instance, there are 14 different administrative units with autonomy regarding education).

The CECE study paralleled the highly influential U.S. study *Running on Empty*[11] that had drawn attention to the state of computer science education in the U.S. The CECE study gathered data from 55 administrative units (countries, nations, and regions) of Europe (plus Israel) with autonomous educational systems through the use of questionnaires and a wide network of reliable contacts and official sources.

The report on that work was published in 2017.[3] The three themes of informatics, digital literacy, and teacher training provided the framework for the study. Informatics was

a In most of Europe, informatics is synonymous with computing or computer science.

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Published in Comm. of the ACM (2019)

Wide dissemination: more than 4K downloads

- Informatics: computational structures, processes, artifacts, and systems
- Industrial machines mechanized physical tasks
- Digital machines mechanize cognitive tasks
- A "two-tier" approach

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Informatics for All: the challenge

A Grand Educational Challenge for Europe

A **two-tier approach**

1. Teach informatics as a **specialized** subject starting in primary all the way up to secondary
2. Teach informatics as a method and language capable to offer an additional and specific way to describe and explain phenomena (**integrated** in other subjects)

- Not at all easy to implement! A thought experiment: imagine Mathematics exists only at the university and plan how to introduce it into all school levels

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HOW? – The «specialization» path

- Other sciences explain the
  - Physical world (matter)
  - Living world (life)
  - Social world (cognition&relation)
- (a set of layered scientific domains)

- Informatics is a discipline of FUNDAMENTAL value, since it's **the science explaining the digital world**
- The 4th big domain of science (computation)

HOW? – The «integration» path

- Informatics is a discipline of TRANSVERSAL value, since it's the only scientific discipline whose abstractions (i.e., models) can be **mechanically and automatically** executed (scenario building and phenomena simulation)
- Through digital models subjects can be learned in novel and more engaging ways
- Computational approaches open doors to new dimensions of understanding and new ways of learning subjects

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http://www.informaticsforall.org

- Brussels workshop February 2019
  - Country presentations: Denmark, England, France, Germany, Israel, Poland, Portugal, USA
- Action plan
  - Enlarging the coalition
  - Fostering research and networking
  - Repository of resources
  - Contacts with other international organizations (including EC)
  - Develop national communities/networks of teachers
- Rome declaration
  - Asking for policy support at national & European level

Informatics for All: areas of intervention

- **Policy & Awareness**
  - Informatics education is fundamental for all (Rome Declaration)
  - Enable common people to understand what Informatics really is
- **Curriculum**
  - Develop fine-grained schools curricula for all levels (and a European meta-curriculum)
  - Develop effective learning materials
- **Teachers**
  - Appropriately educate teachers at all levels
  - Provide all teacher appropriate support (tools and content)
  - Sharing best practices and (national) community building
- **Research**
  - Understand what to teach
  - Understand when to teach
  - Understand how to teach

National workshops & communication

European research & field trials

Support teacher education efforts in member states

European cooperative research & networks

THANKS !!!

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