"Welcome to Nimrod" to Learn CS Ideas in the Middle School

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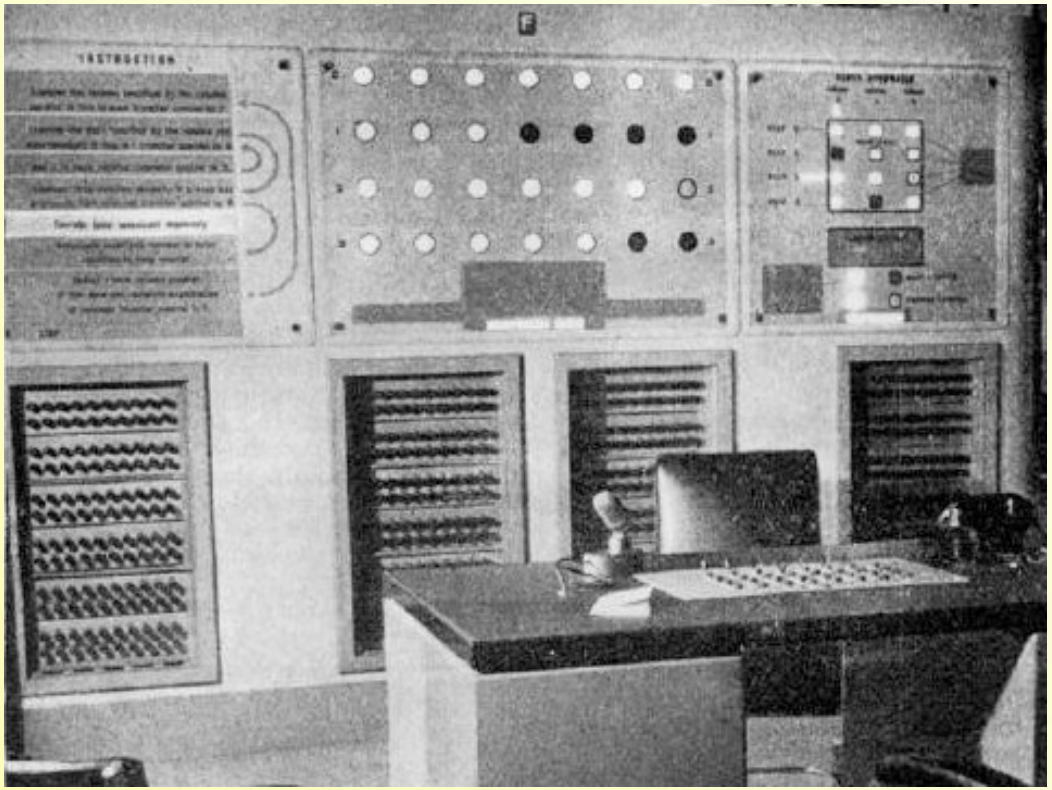
Ferranti NIMROD



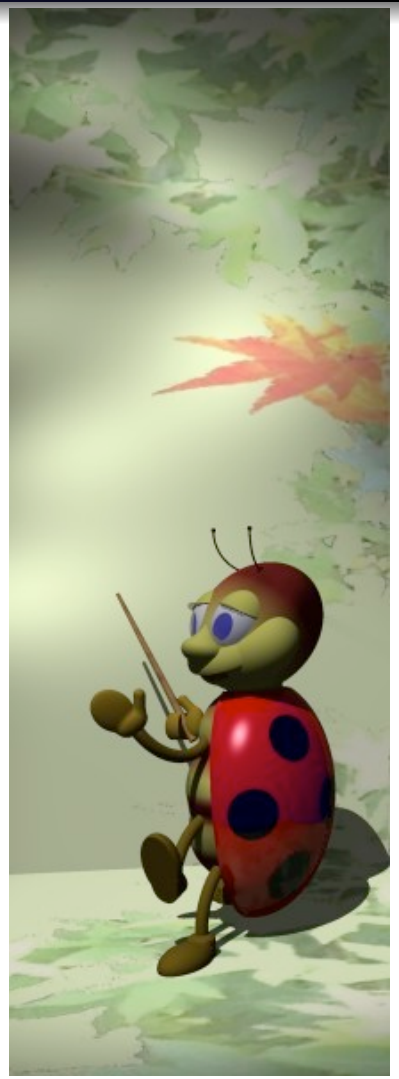
Festival of Britain, London, May 1951

Middle school in Italy

- No separate “informatics” subject
- Some general recommendations in the official programs
- Usually instrumental use of ICT tools (if any)
- Teachers of “Maths and Sciences” have no specific training

Outline

1. Introduction
2. Our approach
   - mental processes before concepts
   - computing history in the background
   - cross-disciplinarity
3. Welcome to Nimrod
   - program structure
   - coordination of a variety of views
   - roles of history
4. Discussion
   - feedback from pupils
   - conclusions



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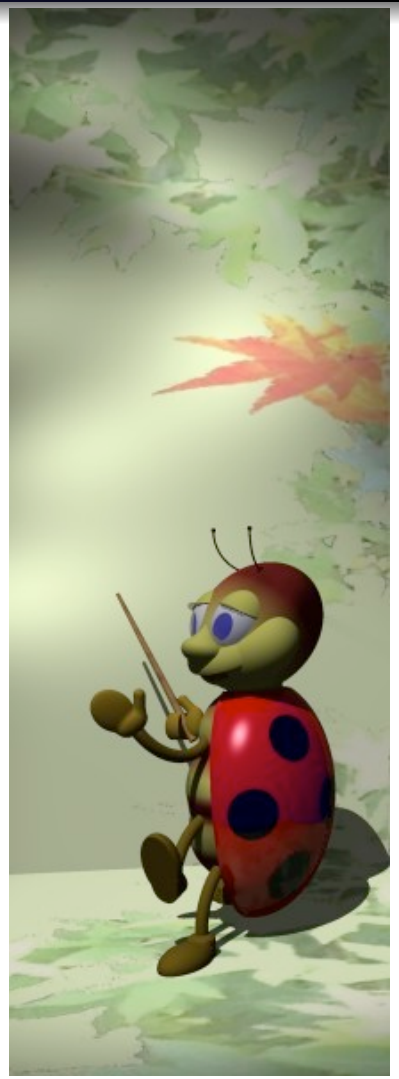


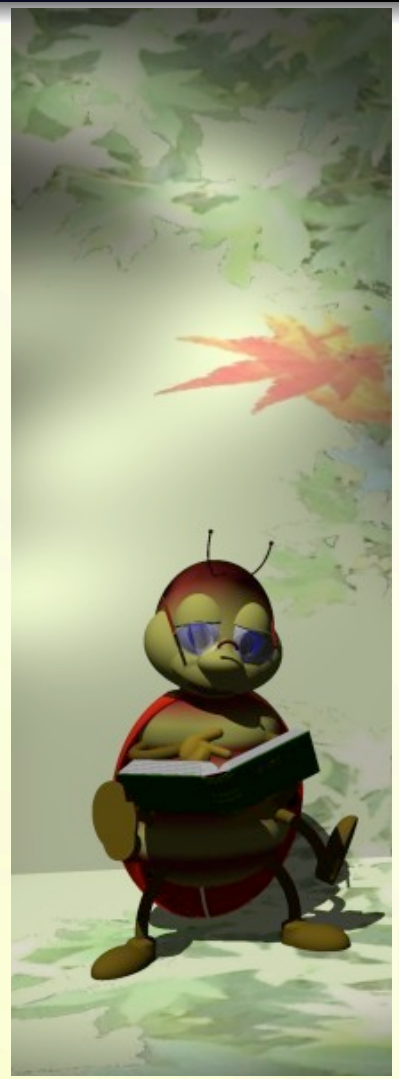
Prelude

"IT mastery is not per se an educational goal [...]

Informatics is an unceasing quest
to disclose the meaning *hidden in a* form*,*
as well as an endeavor
to bind our intended meaning *to some* form*.*

No one should leave school without (at least)
some appreciation of this about informatics."

Charles Duchâteau, 1992



Dexterity with ICTs. . .

"Direct manipulation interfaces [...] *improve the involvement in the operations, but at the price of the illusion that the user can act directly on screen objects, which are based on metaphors* [...].

As a consequence, the actual processing cannot be seen and tends to vanish. There is no real mastery, but just some patch-up job without deep understanding. Since the power of CS relies on the opportunity to have a machine do *some processing, the illusion of* doing directly *is definitely a significant obstacle to the mastery as well as to the understanding of the potential of computers"*

Éric Bruillard, 2006

. . . Or intellectual mastery?

- What idea of processing?
- Objective in the long run:
  intellectual mastery of information processing tasks
- Development of a *cognitive architecture*

Ingredients of our approach: Mental processes

- emphasis on mental processes rather than concepts
- abstraction from “artifacts” of different nature
- “unplugged” activities with cardboard artifacts
- playful tasks to engage pupils
- history of computing as meta-knowledge for teachers
- themes introduced through (hi-)stories
- abstraction from diverse technologies
- cross-disciplinary links to change teachers’ perspective

Ingredients of our approach: History of computing

- emphasis on mental processes rather than concepts
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Ingredients of our approach: Cross-disciplinarity

- emphasis on mental processes rather than concepts
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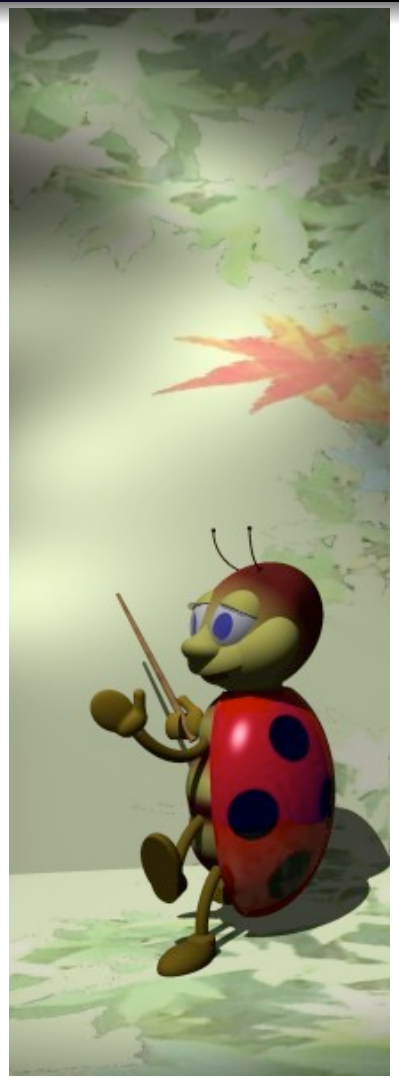
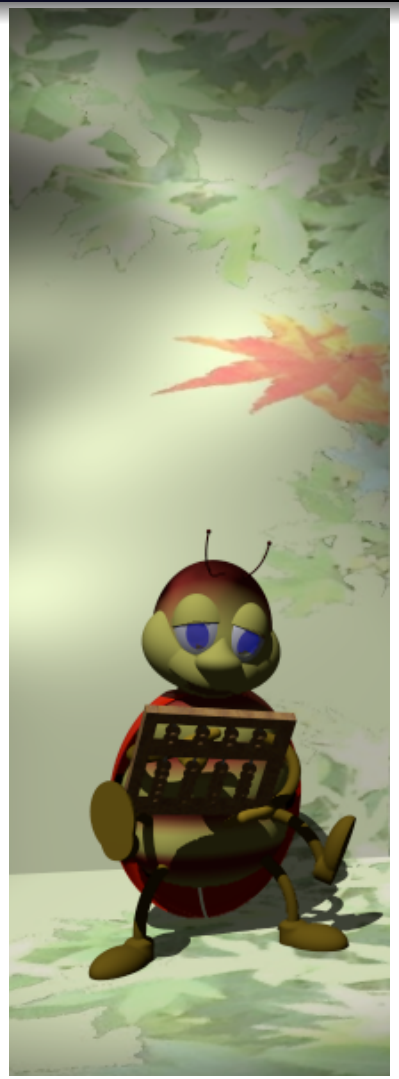


Inspiring work

- CS Unplugged
  (e.g.: Bell et al., 2009)
- CS4FN
  (e.g.: Curzon et al., 2009)
- Informatik erLeben
  (e.g.: Mittermeir et al., 2010)



Duval's analysis of mathematics cognition

"From an epistemological point of view there is a basic difference between mathematics and the other domains of scientific knowledge.

Mathematical objects [...] *are never accessible by perception or by instruments* [...]. *The only way to have access to them and deal with them is using signs and semiotic representations."*

Raymond Duval, 2006

Duval's analysis of mathematics cognition

Two kinds of transformations play a central role:

- treatments
  algorithmic transformations within a semiotic register
- conversions
  based on mappings between different representations (cognitively more complex)

The peculiar thinking processes of mathematics require the cognitive coordination of different semiotic representations

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And what about CS?

treatments – *algorithmic* transformations, Ok. . .

conversions

- basic ideas (information coding, algorithmic processing) are *abstract* in nature, as in mathematics
- CS has constantly to do with mappings between different types of representations of a same entity

Key insights:
it is important to work with heterogeneous representations, including different views of a same algorithmic procedure

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Unplugged computing artifacts

- Duval's semiotic systems can be extended to include all sorts of "glass box" computing artifacts
- Simple "information technology"
  fully within the pupils' reach (unlike the ICT tools)

Why history of computing?

History of a discipline as...

- *repertory* of events to be introduced in a narrative register
- *meta-knowledge* to reflect on instructional methodology

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- *meta-knowledge* to reflect on instructional methodology

History as meta-knowledge

"The history of mathematics may be a useful resource for understanding the processes of formation of mathematical thinking, and for exploring the way in which such understanding can be used in the design of classroom activities."

Luis Radford, 2002

Cross-disciplinarity

- Lower-secondary *informatics* is not a separate subject
- A cross-disciplinary approach to computing is both a need and an opportunity...
- ...helpful to the teachers: unusual CS perspective
- and to the pupils: more critical attitude toward ITs

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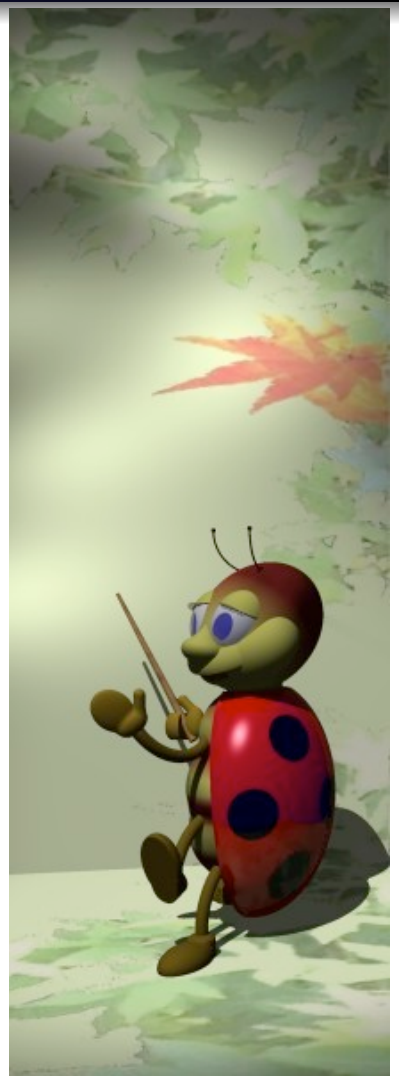

“Welcome to. . . NIMROD” 50 years later

“This is the first digital computer designed specifically to play a game
— truly the very first Computer Game*. . .*

In the process, it illuminates principles of binary arithmetic and digital logic.

So, leave Lara Croft and her friends behind for a while, and journey back to the years BT (Before Transistors), where just to see a computer is an adventure. . .”

Pete Goodeve, 2001–

“Welcome to Nimrod” in the middle school

- Core module of about 20 hours of class work
- Additional material for a further 20 hours
- Work still in progress. . . the teachers are trying to ensure continuity to this experience with their classes

Core module

	Units		Activities
I.	Festival of Britain, London, May 1951	1.	A new game to learn
		2.	Nim player imitation game
		3.	Brainstorming
II.	Bits and strategies	4.	Snippets of computing history
III.	Magic tricks with bits	5.	Cross-disciplinary bridges
IV.	Algorithmic procedures		
			Survey, questionnaire, test

Extended program

Units		Activities	
V.	Surprising power of bit manipulation	6.	Glass-box technology
		7.	Variations on the *"nim"* theme
VI.	Bird's-eye view of a general procedure	8.	A bit of philosophy
			Review test

Extended program

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Units and activities: *More details in the paper. . .*

Cognitive coordination of diverse representations

- **Activity 1**
  A new game to learn
- Unit II
  Bits and strategies
- Unit III
  Magic tricks with bits
- Unit IV
  Algorithmic procedures
- Activity 6
  Glass-box technology

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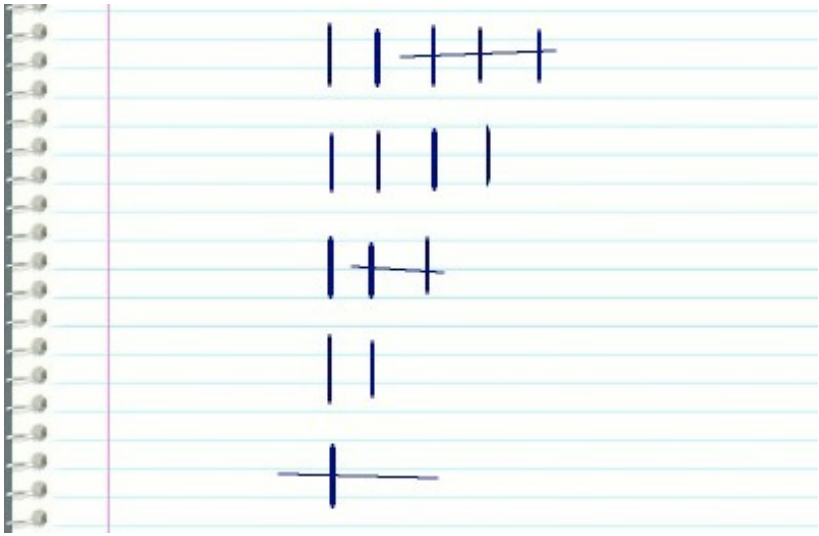

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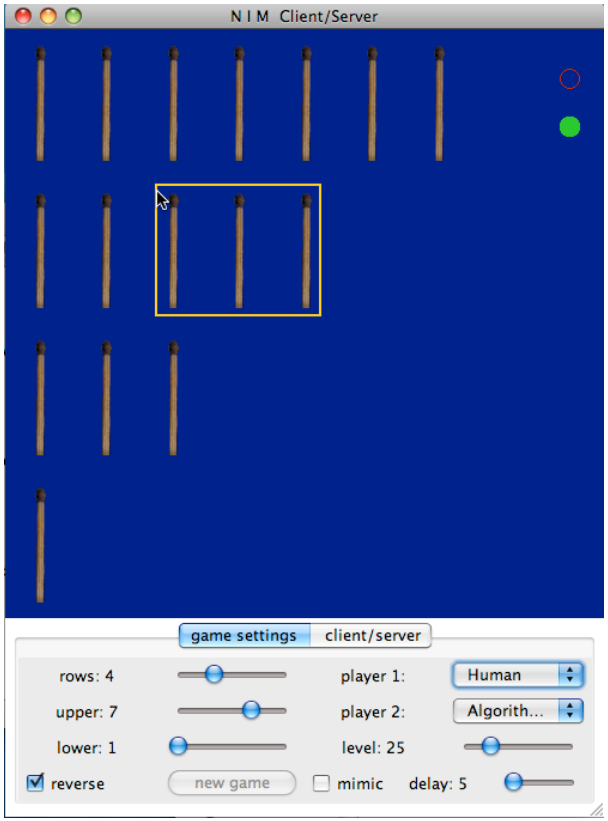

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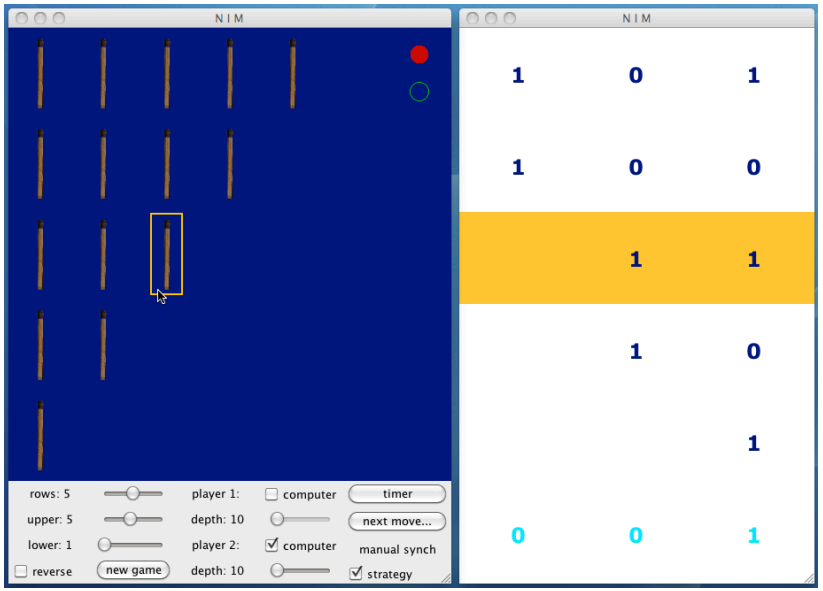

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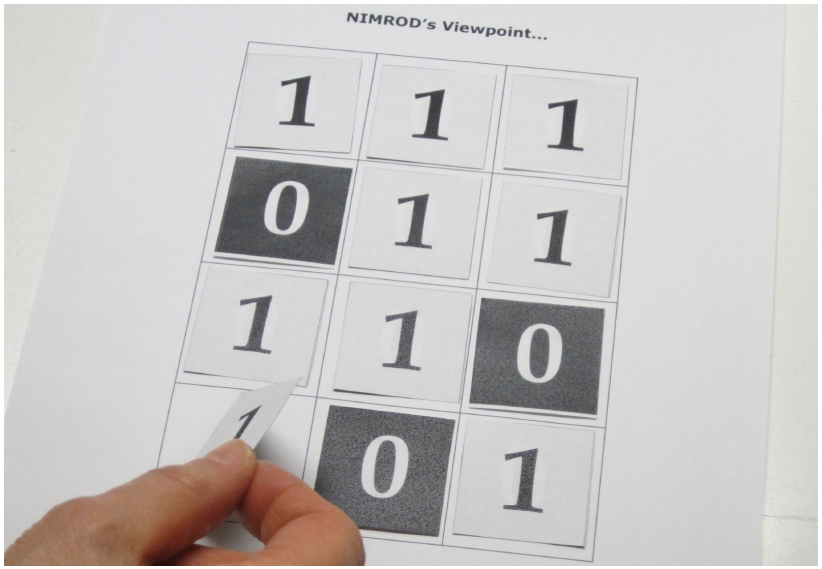

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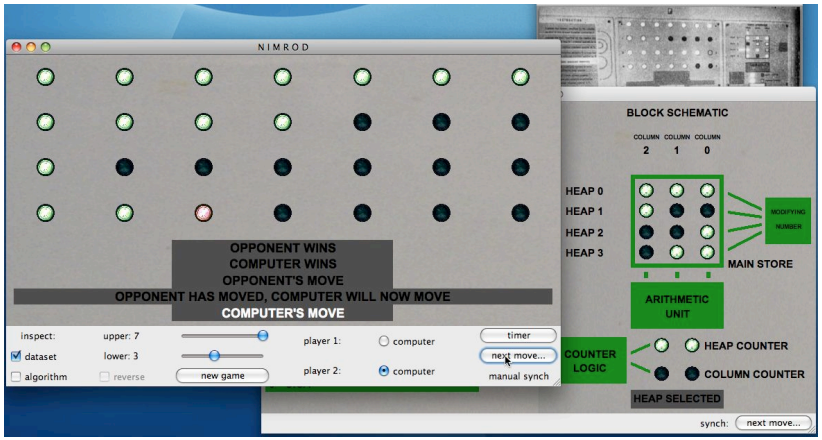

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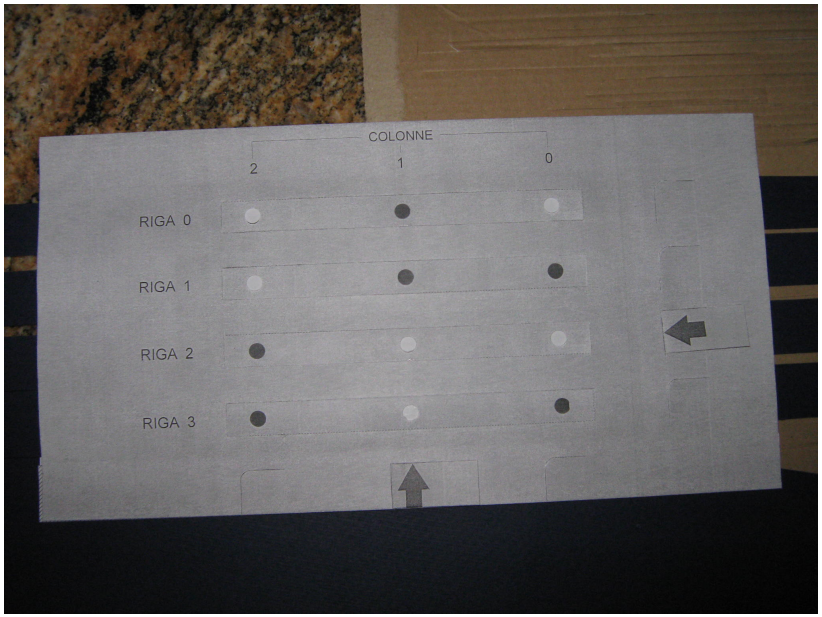

Different views of an algorithmic procedure

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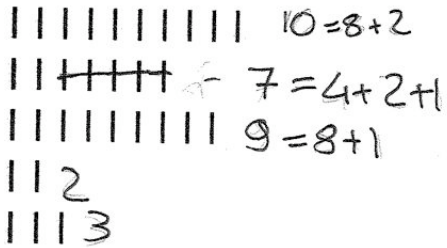

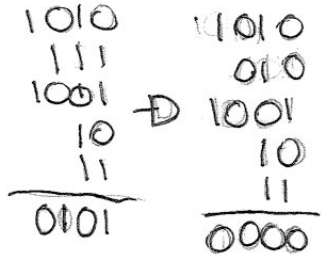

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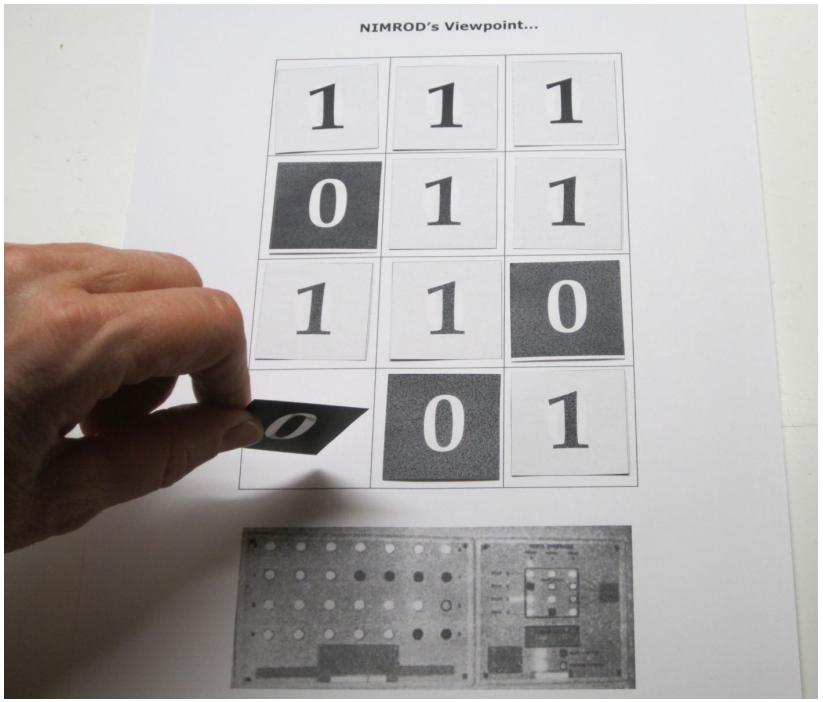

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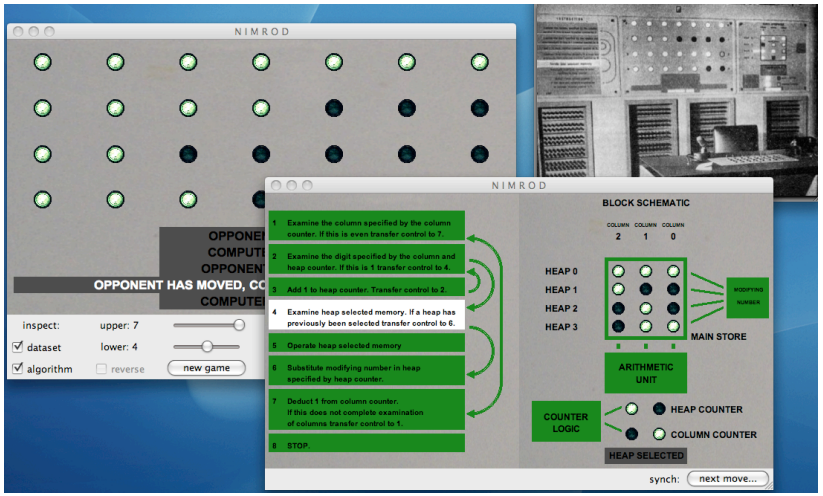

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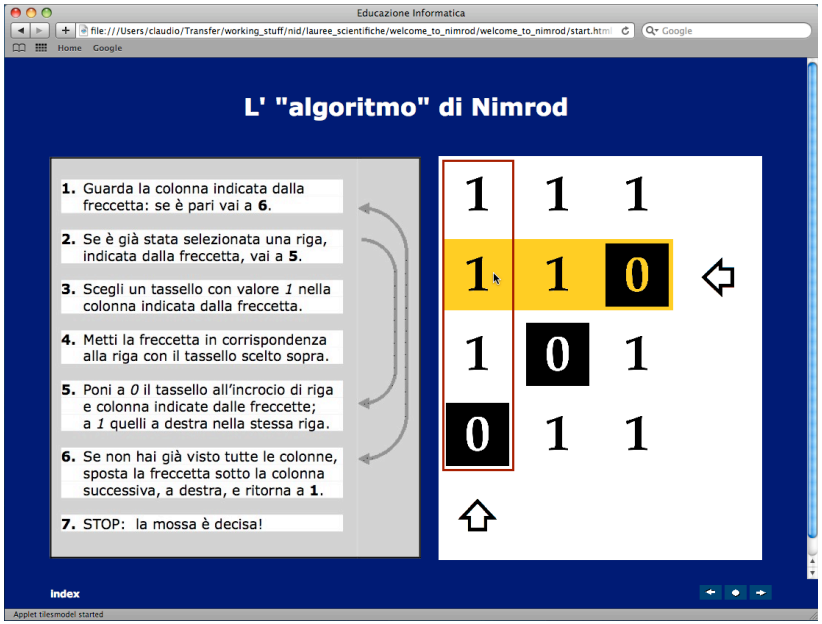

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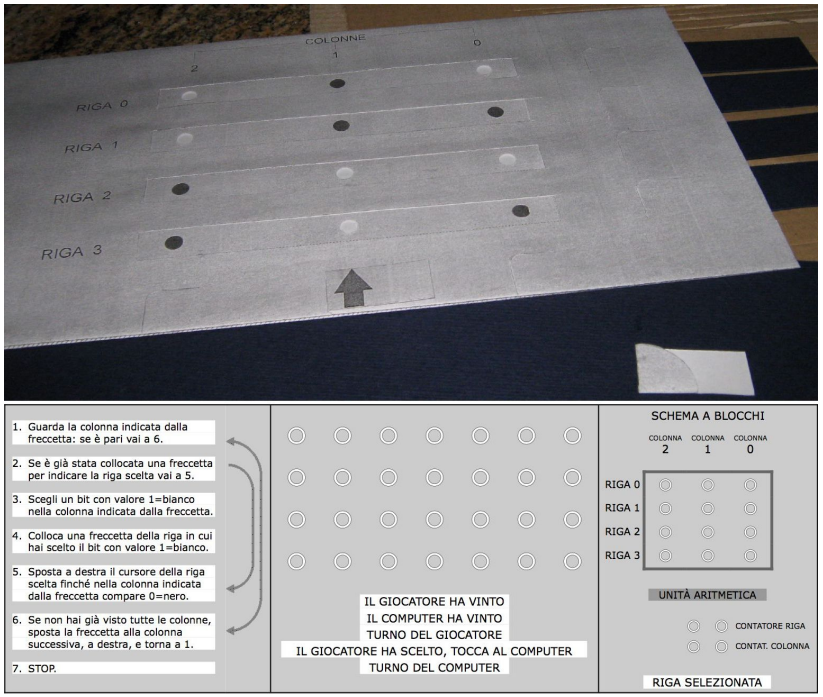

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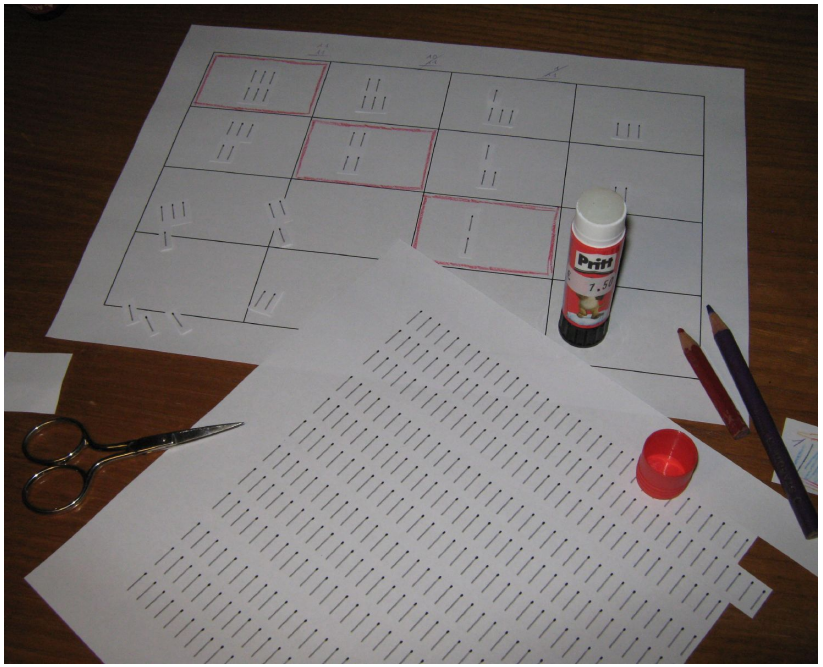

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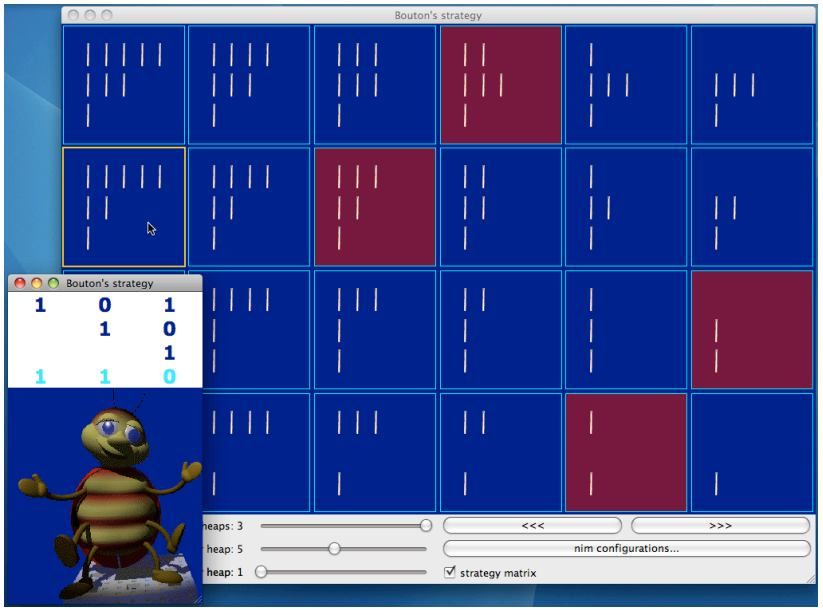

History as meta-knowledge

- *Signs*: retaining information outside the human mind
  data vs. information; nature, structure and scope of codes...
- *Rules*: disclosing new information outside the mind
  formal treatment and artifacts; amenability to manipulation...
- *Mechanisms*: processing information outside the mind
  informational perspective; automation of simple tasks...
- *Programs*: controlling plan-execution outside the mind
  introspection and verbalization of algorithmic tasks...
- *Programs-as-data*: abstraction outside the mind
  universal machine; abstraction levels and forms...
- *Complex systems*: intelligence outside the human mind?
  management of complexity; toward artificial intelligence...

Signs & rules: Elementary school level

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Rules, Mechanisms & Programs: Middle school level

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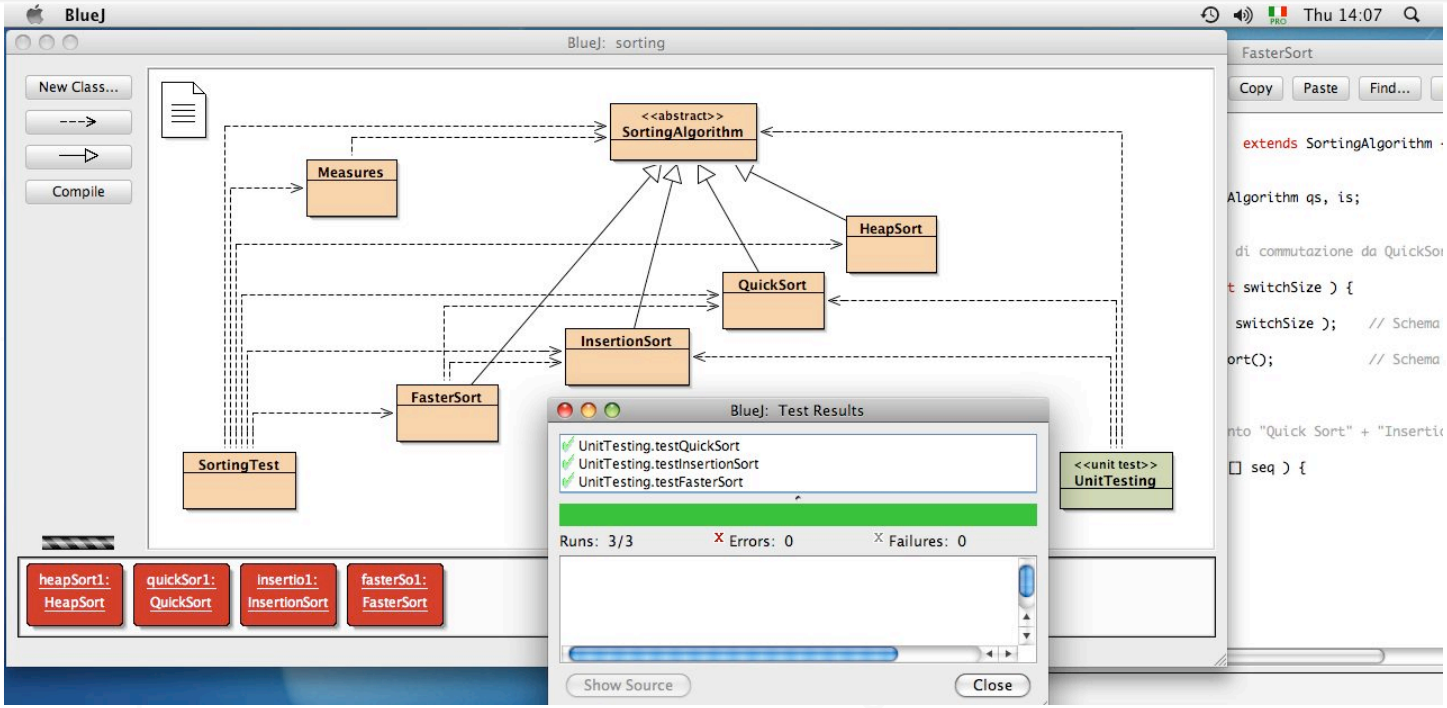
Later...



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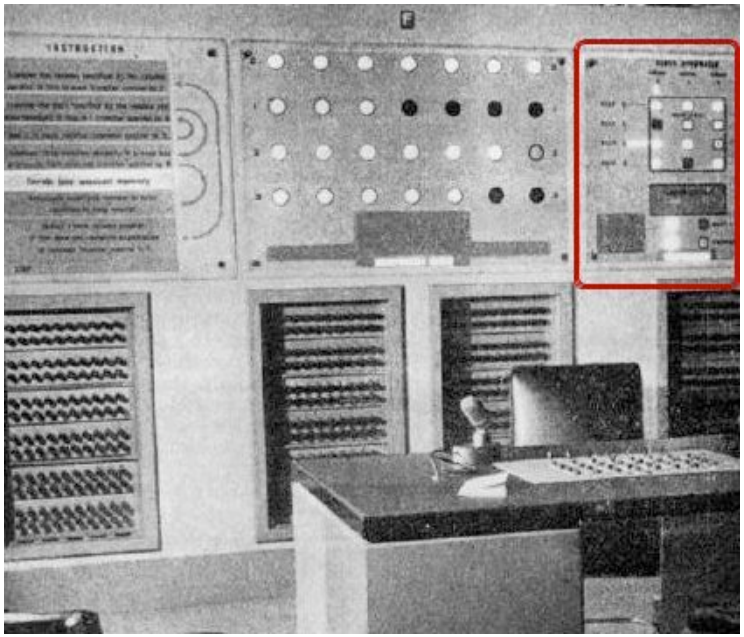
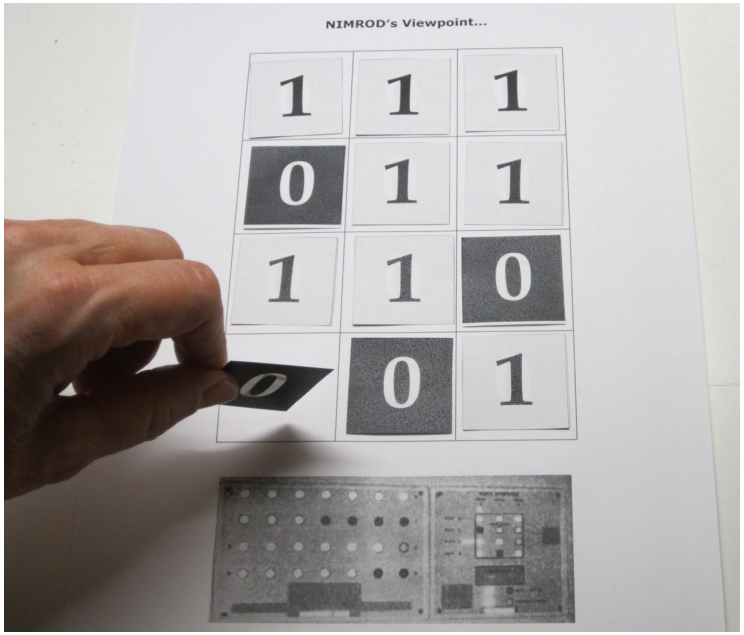
Rules: . . . “amenability to manipulation”

Nimrod

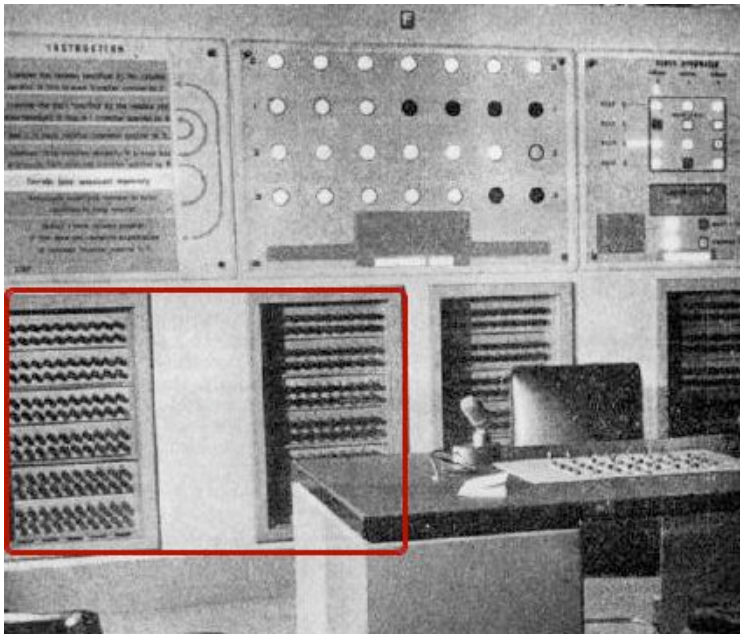


Unplugged



Mechanisms: . . . automation of tasks

Nimrod



Unplugged

Programs: . . . algorithmic procedures

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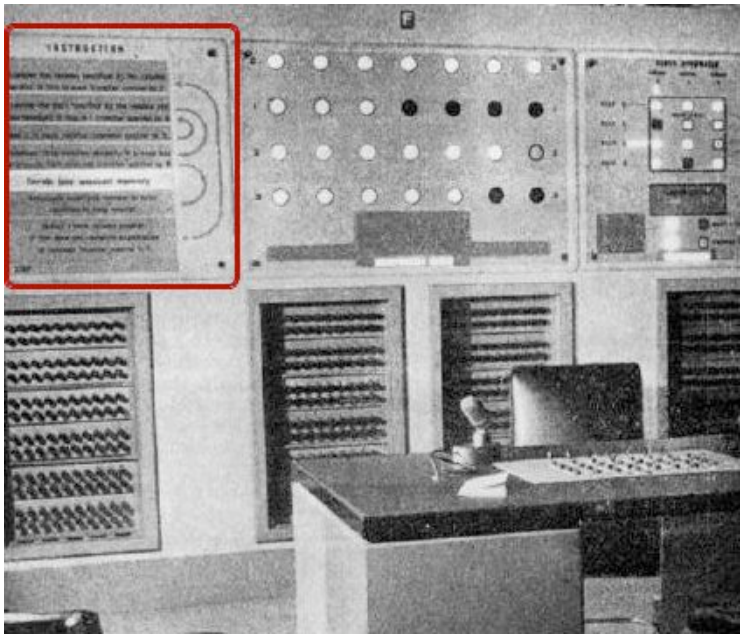

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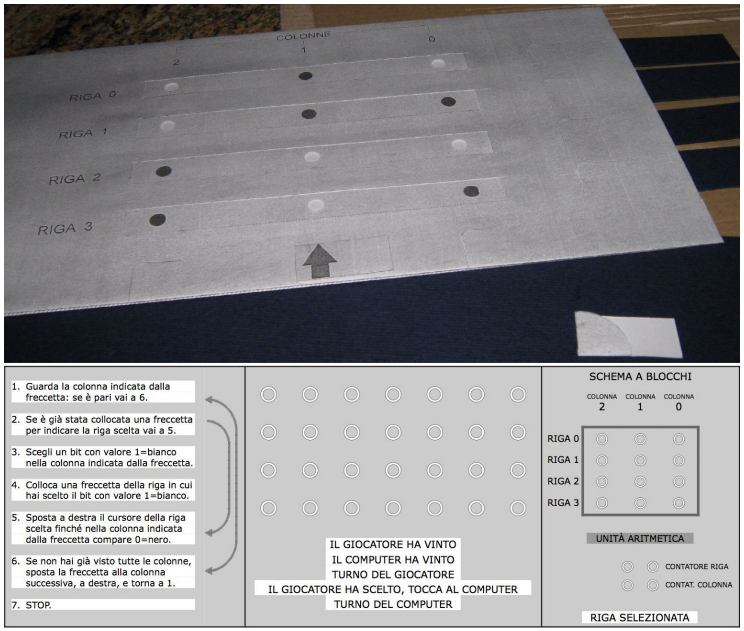
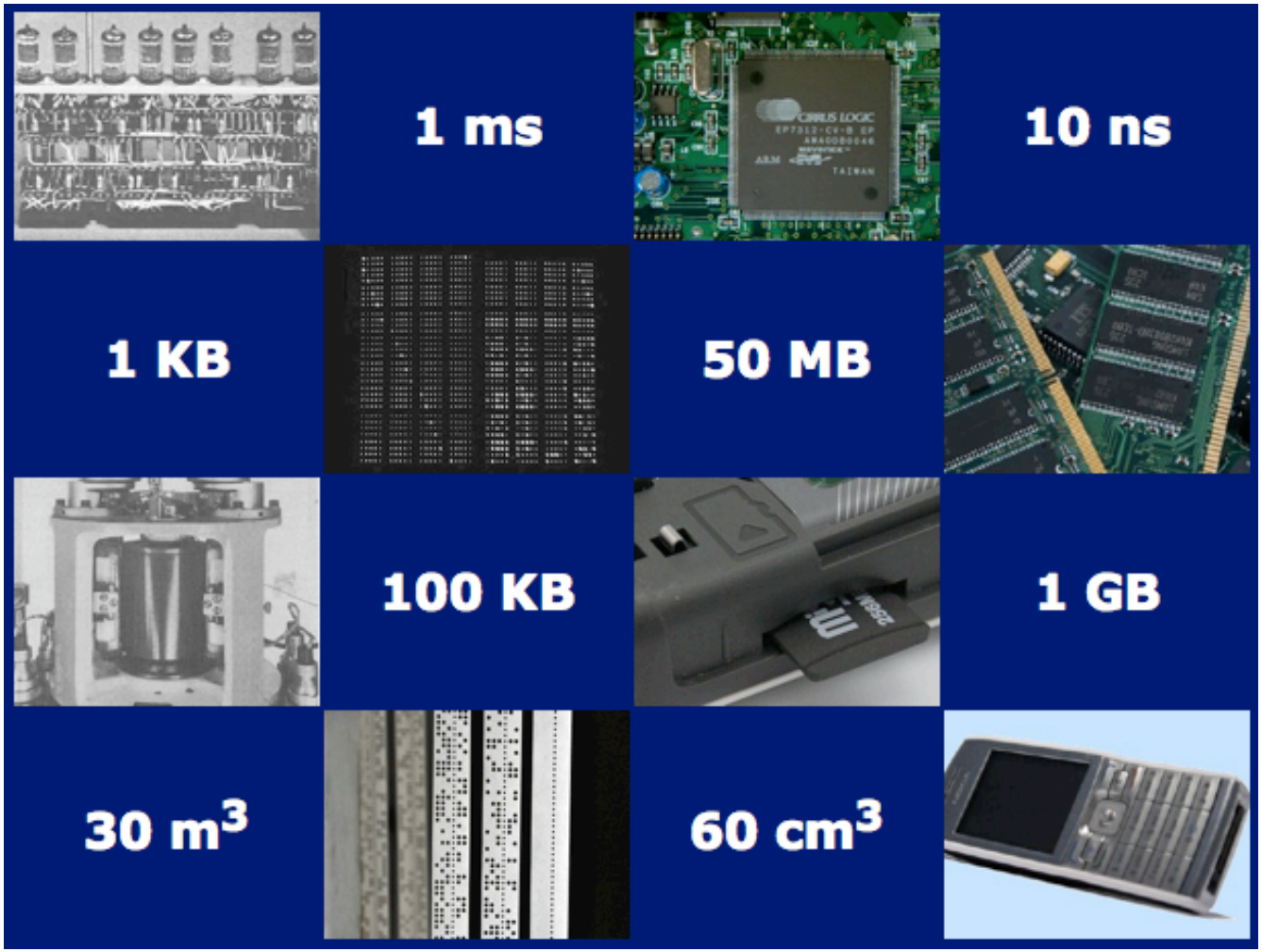


Contingent technologies vs. stable principles



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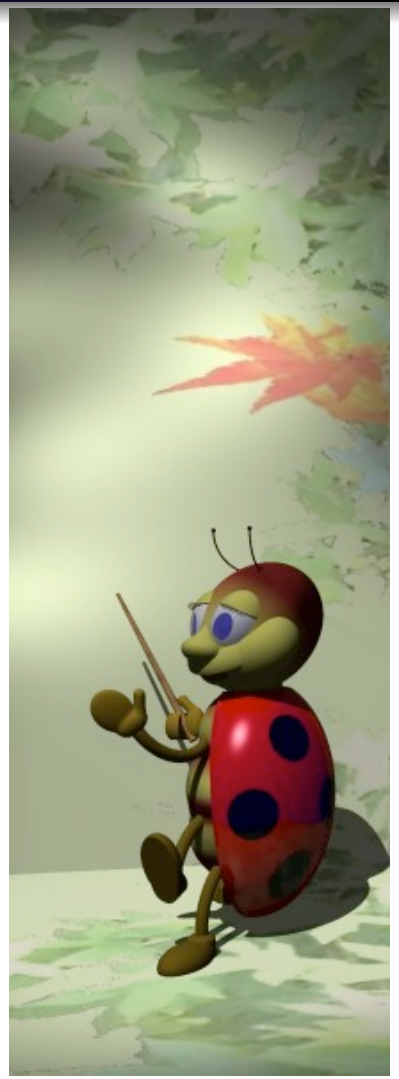

Experience

- A few figures:
  - 5 teachers and 138 children of three middle schools
  - Larger program with 4 classes in s.y. 2011–12 (83 sixth-graders, age 11–12) and 2012–13
  - Core module with further 3 classes in s.y. 2010–11 (+ P4C; 33 eighth-graders) and 2012–13 (33 seventh-graders)
- Feedback:
  - From pupils: direct observation, questionnaires, exercises, tests
  - From teachers: meetings, PLS questionnaire

Experience

- A few figures:
  - 5 teachers and 138 children of three middle schools
  - Larger program with 4 classes in s.y. 2011–12 (83 sixth-graders, age 11–12) and 2012–13
  - Core module with further 3 classes in s.y. 2010–11 (+ P4C; 33 eighth-graders) and 2012–13 (33 seventh-graders)
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What kind of feedback from pupils?

- Not yet sufficient for a full assessment of the impact on pupils' attitudes toward the sphere of computing
- But, it may tell us something about the achievement of particular objectives:
  - *engagement*
  - *appropriateness*
  - *topics of interest*
  - *outreach*

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Engagement

Quite high engagement...

- General project survey (PLS):
  - the overall experience was *worth doing* (> 90% of positive answers)
  - the themes were *interesting* (> 90% of positive answers)
- Specific perception questionnaire:
  - every kind of activity was *meaningful* to several (> 1/4) pupils
- Direct observation!

Appropriateness

Mostly appropriate for the age range...

- General project survey (PLS):
  - a few pupils (about 1/3) found some difficulties
  - ...but teachers clear and material adequate (> 90% of positive answers)
- The teachers think so

Topics of interest

Several themes turned out to be appealing

- Perception questionnaire (*open* answers):
  - computing history
  - technological change
  - structure and potential of computers
- Interactions with researcher and teachers

Outreach

Maybe some outreach potential?

- Perception questionnaire:
  - Most pupils report having changed their view of *informatics* (2/3 vs. 1/5 of mathematics)
  - Interesting spontaneous questions:

    “Why computers do not make errors?”

    “How is it possible to attain such a high density of integration in the digital devices?”

    “Which are the future perspectives of computing?”

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Content-specific issues

- Review tests:
  - about 2/3 of the pupils master Bouton's strategy
  - as well as Nimrod's dataset
  - . . . but about half the pupils are unable to follow a *precise* sequence of algorithm steps
- Investigation of nim variants and strategies (questionnaire):
  - apparently difficult for middle-schoolers
- More figures in the paper. . .

Competence issues

Competences attained in the formal operational stage may not yet be well developed:

- systematic case analysis
- understanding of transformations of transformations
- verbalization and precise description of a procedural task

Re-designing some tasks?

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Peculiar activities

- *Nim player imitation game*
  - not easy to see if the opponent is the computer!
  - a computer should play faster and better...
- *Surprising power of bit manipulation* (Josephus problem)
  - ...and surprising findings by a couple of girls
- *Bird's-eye view of a general procedure*
  - how not to get lost while enumerating the configurations?
- *A bit of philosophy* (P4C)
  - appropriate for 8th-graders
    who are constructing their identity
  - interesting links with Turing's seminal paper...

Teachers' feedback

From:

- Discussions during the meetings
- PLS anonymous questionnaire

Above all: they are working enthusiastically

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Conclusions

Gratifying experience:

- Seems to have been beneficial to pupils:
  high engagement in the proposed tasks. . .
- . . . But also to the teachers:
  different view of “informatics”
- Still work in progress. . .
- It would be interesting to study appropriate instruments
  to assess the program from an edu-research perspective

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Thanks for your patience. . .

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