Informatics – New Basic Subject

Walter Gander

ETH Zurich and BU Hong Kong

International Colloquium
SEII+AGORIA
Belgium
November 19, 2014
Computers have been invented . . .

for computing!
Two Computer Pioneers

Howard Aiken, physicist:
constructor of the Harvard Mark I, 1944
system of differential equations with 4 functions,
no analytic solution,
⇒ compute numerical approximation

Konrad Zuse, civil engineer:
constructor of the Z3 (first programmable computer
using binary floating point numbers, 1941)
“large” \((n \approx 20)\) linear systems of equations,
⇒ compute solution
Start of CS in Switzerland
Zuse’s Z4 at ETH
leased 1950-1955 by E. Stiefel
collaborators:
A. Speiser, H. Rutishauser (1955)
Developer of Programming Languages

One of the fathers of ALGOL

Handbook Series Vol 1:

Heinz Rutishauser
Description of ALGOL 60, 1967

PASCAL: Report by Niklaus Wirth and Kathleen Jensen, 1975

MODULA: Programming in Modula-2
Niklaus Wirth, 1982

OBERON: J. Gutknecht, N. Wirth:
Project Oberon. The Design of an Operating System and Compiler, 1992
CS Education in Switzerland

- In spite of impressive pioneering achievements no immediate influence on education
- University: Introduction of a CS-curriculum at ETH only 1981
- Schools: Slide rule slowly replaced by pocket computer
- Gymnasium:
  - 1984 planning for computer science in STEM-oriented tracks
  - 1986 Urs Hochstrasser renames Descriptive Geometry to Applied Mathematics
CS in Gymnasia 1986

- PC with almost no applications
  - therefore main activity:
    - system installation
    - programming in BASIC or PASCAL
- produced some enthusiastic high-school students; now good computer scientists
- frustrated teachers:
  - frequent breakdowns and system changes
  - students nerds know more
Development after 1995

- many applications available, no need to develop themselves
- computer cheaper, ubiquitous and easier to handle (e.g. Macintosh)
- INTERNET and WEB are available
- strong movement: no need to learn programming anymore
- instead: learn to make good use of computer tools $\Rightarrow$ ICT
- applications become more complex, teachers have to be trained
- Intel and Microsoft offer training for their products to whole countries
Verkommert der Schüler zum Computerbenutzer?
Fragwürdiger Paradigmenwechsel im Informatikunterricht

Von Walter Gander, Vorsteher der Abteilung für Informatik, ETH Zürich


Dr. H. J. Tobler von der Firma Finajour sagt es noch deutlicher in seinem Referat mit dem Thema «Die drohende Andorrisierung der Schweiz». In der Zusammenfassung zu seinem Vortrag schreibt er:

Mit der vorgeschlagenen möglichen Wegwahl von naturwissenschaftlichen Fächern bewegen wir uns in Richtung des Modells der amerikanischen Highschool, welche keinen guten Ruf hat.

An der letzten GEP-Vorlesung beklagte Prof. N. Negroponte (MIT Media Laboratory) die schlechte Ausbildung der Jugendlichen in den USA. Von der Schule verlangte er ein Umdenken, eine Modernisierung des Unterrichts. Er stellte fest, dass ein Lehrer im wesentlichen gleich unterrichte wie im letzten Jahrhundert, dass aber beispielsweise ein Arzt vom vorigen Jahrhundert sich nicht mehr in einem modernen Operationssaal zurechtfähne. Prof. Negroponte forderte intelligente Spielzeuge und zeigte Beispiele von kleinen Kindern, die selber Steuerungen für ihre LEGO-Fahrzeuge bauten.
Unease grows in Education and Industry

- ETH: many freshmen, many drop out – wrong picture of CS!
- Industry misses workforce, ICTSwitzerland position paper 2010:

Positions papier der Kommission Bildung zur Informatik an Gymnasien

Zielsetzung
- Förderung des Informatikunterrichts an den Schweizer Gymnasien,
- Auslöschung von Massnahmen für eine rasche Einführung eines Grundlagenfachs Informatik und eines Schwerpunktfachs Informatik an den Schweizer Gymnasien,
- Unterstützung des Positions- papier durch den Vorstand von ICTswitzerland und Verbreitung.

Zielgruppen
- Bildungspolitikerinnen und -politiker, Bildungsbehörden, Bildungsinstitutionen, Schulleitungen, Informatiklehrkräfte und deren Verbände, Medien.
Michael Gove
Secretary of State for Education in UK

Speech of January 2012

⇒ Turning point

- the UK had been let down by an ICT curriculum that neglects the rigorous computer science and programming skills which high-tech industries need.

- In short, just at the time when technology is bursting with potential, teachers, professionals, employers, universities, parents and pupils are all telling us the same thing: ICT in schools is a mess.

Michael Gove (cont.)

- The new Computer Science courses will reflect what you all know: that Computer Science is a rigorous, fascinating and intellectually challenging subject

- Initiatives like the Raspberry Pi scheme\(^a\) will give children the opportunity to learn the fundamentals of programming with their own credit card sized, single-board computers. It could bring the same excitement as the BBC Micro did in the 1980s\(^b\)

- Imagine the dramatic change which could be possible in just a few years, once we remove the roadblock of the existing ICT curriculum. Instead of children bored out of their minds being taught how to use Word and Excel by bored teachers, we could have 11 year-olds able to write simple 2D computer animations using an MIT tool called Scratch. 

\(^a\) ICT↔CS: David Braban

\(^b\) also: Commodore 64, Amiga …
What is Computer Science? What should be taught in schools?

- The “Informatics Europe & ACM Europe Working Group” defined in their report (April 2013): [a]

  Computer Science in Schools = Digital Literacy + Informatics

- Digital Literacy (often called ICT) is about the use of computers
- Informatics covers the science behind information technology
- Both parts should be taught compulsory in European schools for all students from first grade on

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Rapport de l'Académie des sciences

L’enseignement de l’informatique en France

Il est urgent de ne plus attendre

MAI 2013

Préambule


Le rapport traite de la place de l’informatique dans les enseignements primaire et secondaire, ainsi que de la formation de leurs professeurs. Il évoque également brièvement l’enseignement supérieur (classes préparatoires et universitaires), sujet qui mériterait de plus amples développements.

Le groupe de travail est composé d’académiciens, de chercheurs et d’enseignants : Serge Ahituv (académicien, Inria), Jean-Pierre Archambault (association EPI, Enseignement public & informatique), Christine Balagné (Institut Télécom), Georges-Louis Baro (université René Descartes, Paris), Gérard Berry (académicien, Collège de France), Gilles Dowek (Inria), Colin de la Higuera (SIF - Société informatique de France - et université de Nancy), Maurice Nivat (académicien), Françoise Tort (École normale supérieure de Cachan), Thierry Viéville (Inria). Gérard Berry en assure la présidence et Gilles Dowek le secrétariat.

http://www.academie-sciences.fr/activite/publi.htm
Fakultätentag Informatik
der Universitäten in der Bundesrepublik Deutschland e.V.

Der Vorsitzende
Prof. Dr. Hans-Ulrich Heiß
TU Berlin
Einsteinufer 17 / EN6
D-10717 Berlin

Informatik in der Schulbildung:
Wir dürfen den Anschluss nicht verlieren!

Resolution des Fakultätentags Informatik
November 2013

https://www.ft-informatik.de/52.html
George Forsythe wrote 1963:

Machine-held strings of binary digits can simulate a great many kinds of things, of which numbers are just one kind. For example, they can simulate automobiles on a freeway, chess pieces, electrons in a box, musical notes, Russian words, patterns on a paper, human cells, colors, electrical circuits, and so on. To think of a computer as made up essentially of numbers is simply a carryover from the successful use of mathematical analysis in studying models ... Enough is known already of the diverse applications of computing for us to recognize the birth of a coherent body of technique, which I call computer science. 

\[ \text{\textsuperscript{\textalpha}} \]

\[ \text{\textsuperscript{\textalpha}Educational implications of the computer revolution. Applications of Digital Computers, W. F. Freiberger and William Prager (eds.), Ginn, Boston, 1963, pp. 166-178.} \]
A Textbook of 1969/1975! more than 40 years ago!!
Programming – a Fundamental of Informatics!

George Forsythe 1959: The automatic computer really forces that precision of thinking which is alleged to be a product of any study of mathematics.\(^a\)

George Forsythe 1966: The major thing which distinguishes computer science from other disciplines is its emphasis on algorithms.

There are few problems for which a good algorithm of probable permanent value is known... Small details are of the greatest importance... The development of excellent algorithms requires a long time, from discovery of a basic idea to the perfection of the method... A useful algorithm is a substantial contribution to knowledge. Its publication constitutes an important piece of scholarship.\(^b\)

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\(^a\) The role of numerical analysis in an undergraduate program. Amer. Math. Monthly 66 (1959), 651-662.

\(^b\) Algorithms for scientific computation. CACM 9 (Apr. 1966), 255-256.
Now 2014: Programming is again very popular worldwide!

The New York Times | http://nyti.ms/1jsvs4V

U.S. | NYT NOW

Reading, Writing, Arithmetic, and Lately, Coding

By MATT RICHTEL  MAY 10, 2014

MILL VALLEY, Calif. — Seven-year-old Jordan Lisle, a second grader, joined his family at a packed after-hours school event last month aimed at inspiring a new interest: computer programming.

“T’m a little afraid he’s falling behind,” his mother, Wendy Lisle, said, explaining why they had signed up for the class at Strawberry Point Elementary School.
Everybody Should Learn to Program

Leaders and trendsetters agree more students should learn to code

President Bill Clinton
“At a time when people are saying ‘I want a good job - I got out of college and I couldn’t find one,’ every single year in America there is a standing demand for 120,000 people who are training in computer science.”

Marco Rubio
Senator, Florida
“Computer programmers are in great demand by American businesses, across the tech sector, banking, entertainment, you name it. These are some of the highest-paying jobs, but there are not enough graduates to fill these opportunities.”

Bill Gates
Chairman, Microsoft
“Learning to write programs stretches your mind, and helps you think better, creates a way of thinking about things that I think is helpful in all domains.”

Mark Zuckerberg
Founder, Facebook
“Our policy at Facebook is literally to hire as many talented engineers as we can find. There just aren’t enough people who are trained and have these skills today.”

WILL.I.AM
Musician/The Black Eyed Peas and Entrepreneur
“Here we are, 2013, we ALL depend on technology to communicate, to bank, and none of us know how to read and write code. It’s important for these kids, right now, starting at 8 years old, to read and write code.”

Sheryl Sandberg
Chief Operating Officer, Facebook
“An understanding of computer science is becoming increasingly essential in today’s world. Our national competitiveness depends upon our ability to educate our children – and that includes our girls – in this critical field.”

Vice President Al Gore
“Our civilization is experiencing unprecedented changes across many realms, largely due to the rapid advancement of information technology. The ability to code and understand the power of computing is crucial to success in today’s hyper-connected world.”

Chris Bosh
NBA All-star, Miami Heat
“Coding is very important when you think about the future, where everything is going. With more phones and tablets and computers being made, and more people having access to every thing and information being shared, I think it’s very important to be able to learn the language of coding and programming.”

+ 756’432 others . . .

A pledge for Programming by Celebrities  Short version
President Obama: a

High Schools Should Offer Programming and Graphic Design Courses b

Given how pervasive computers and the Internet is now and how integral it is in our economy and how fascinated kids are with it, I want to make sure that they know how to actually produce stuff using computers and not simply consume stuff…

We’re going to start setting those programs in our high schools, not waiting to go to community college.

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aFireside Hangout on Google+, Mountain View, Feb 2013
bhttp://tinyurl.com/pgf2cx2
The European Commission (EC) is urging people to learn coding this Summer, warning that a lack of basic coding skills could result in Europe facing a shortage of up to 900,000 ICT professionals by 2020.

Coding is the literacy of today and key to enable the digital revolution, according to European Commission vice president for Digital Agenda, Neelie Kroes, and commissioner for education, culture, multilingualism and youth, Androulla Vassiliou.

Programming is everywhere and fundamental to the understanding of a hyper-connected world, the EC has said.

EU Code Week, taking place across Europe 11-17 October 2014

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*a* Article in ComputerWeekly by Archana Venkatraman, 30 July 2014, [http://tinyurl.com/mhq3tub](http://tinyurl.com/mhq3tub)

*b* EU Code Week
Why is Programming IMPORTANT for General Education?

- Not for increasing the IT-workforce! (Though also badly needed)
  Teaching mathematics, physics, chemistry, biology is also not for increasing workforce but for understanding our world.

- Programming is an activity which is
  - creative and
  - constructive
  and teaches
  - precise working and
  - computational thinking
Computational Thinking: Topic of General Education.

• Definition by Jan Cuny, Larry Snyder, and Jeannette M. Wing

> 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.

• Singapore Management University!

> Computational thinking is about problem solving that uses fundamental concepts in computer science, such as abstraction, decomposition, recursion, heuristic reasoning, just to name a few. It can be used to algorithmically solve complex problems of scale, and is often used to realize large improvements in efficiency.

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<sup>a</sup> Carnegie Mellon University, USA, [http://www.cs.cmu.edu/~CompThink/](http://www.cs.cmu.edu/~CompThink/)

<sup>b</sup> [http://sis.smu.edu.sg/computationalthinking](http://sis.smu.edu.sg/computationalthinking)
Computational Thinking is for Everybody

• Jeannette M. Wing wrote in CACM [a]
  Computational Thinking represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use.

• Computational thinking: a methodology for anyone for solving problems with computers. It involves the following steps
  – Analyze a task or problem, model and formalize it.
  – Search for a way to solve it, find or design an algorithm.
  – Program.
  – Run the program: let the computer work, maybe correct, modify the program.
  – Interpret the results.

New Curriculum in Switzerland 07.11.2014

http://www.lehrplan.ch/

### Lehrplan 21

#### Startseite

|-----------|-----------|-----------|

#### Sprachen

| Deutsch | Französisch | Englisch | Italienisch |

#### Mathematik

#### Natur, Mensch, Gesellschaft

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#### Gestalten

| Bildernisches Gestalten / Textiles und Technisches Gestalten |

| Musik |

| Bewegung und Sport |

| Medien und Informatik |

| Berufliche Orientierung |

#### Bildung für Nachhaltige Entwicklung

#### Überfachliche Kompetenzen

Personale, Soziale, Methodische Kompetenzen
1 | Medien

1. Die Schülerinnen und Schüler können sich in der physischen Umwelt sowie in medialen und virtuellen Lebensräumen orientieren und sich darin entsprechend den Gesetzen, Regeln und Wertesystemen verhalten.

2. Die Schülerinnen und Schüler können Medien und Medienbeiträge entschlüsseln, reflektieren und nutzen.


4. Die Schülerinnen und Schüler können Medien interaktiv nutzen sowie mit anderen kommunizieren und kooperieren.

2 | Informatik

1. Die Schülerinnen und Schüler können Daten aus ihrer Umwelt darstellen, strukturieren und auswerten.

2. Die Schülerinnen und Schüler können einfache Problemstellungen analysieren, mögliche Lösungsverfahren beschreiben und in Programmen umsetzen.

Informatics as New Basic Subject in Schools?

• Opposition
  – Expensive: support, maintaining equipment, license fees
  – Policy makers often don’t know what programming means. They also often don’t know the difference between digital literacy (ICT) and informatics
  – Why is ICT necessary? Kids learn the handling of the new devices anyway by themselves.

• Greek solution: eliminate ICT lessons from schools.
  Easy way to save money.
  Solution for poor countries? Resign and give up education in the essential technology for innovations?
Alternative

- Training computational thinking and problem solving does not need expensive equipment.
- Inexpensive computer like Raspberry Pi for $25.–:
- Public domain software is free of charge:
  - Linux operating system
  - LibreOffice (successor of OpenOffice)
    [http://www.libreoffice.org](http://www.libreoffice.org)
  - \LaTeX\ for professional typesetting
  - Logo, Pascal, Octave, Python, ... many public domain programming languages
Google engineer **Neil Fraser**
(March 2013, visiting Vietnamese high school kids) [a](http://www.theregister.co.uk/2013/03/22/vietnam_kids_google_interview_pass/)

- **Problem:** “Given a data file describing a maze with diagonal walls, count the number of enclosed areas, and measure the size of the largest one.”

- The class had 45 minutes to design a solution and implement it in Pascal. Most of them finished, a few just needed another five minutes. **There is no question that half of the students in that grade 11 class could pass the Google interview process.**

- If nothing else, this snapshot into the Vietnamese school system shows what can be done despite limited funds.
Final Comments and Recommendations

Report of Informatics Europe and ACM Europe:

- European nations are harming their primary and secondary school students, both educationally and economically, by failing to offer them an education in the fundamentals of informatics.

- Continuation of this failure would put the European economy at risk by causing students to lag behind those of many other countries, including emerging but increasingly competitive countries (India is the most obvious example but by far not the only one).

- Informatics education must become, along with digital literacy, an obligatory part of general education.
Final Comments and Recommendations (cont.)

**Recommendation 1.** All students should benefit from education in digital literacy, starting from an early age and mastering the basic concepts by age 12. Digital literacy education should emphasize not only skills but also the principles and practices of using them effectively and ethically.

**Recommendation 2.** All students should benefit from education in informatics as an independent scientific subject, studied both for its intrinsic intellectual and educational value and for its applications to other disciplines.
Final Comments and Recommendations (cont.)

**Recommendation 3.** A large-scale teacher training program should urgently be started. To bootstrap the process in the short term, creative solutions should be developed involving school teachers paired with experts from academia and industry.

**Recommendation 4.** The definition of informatics curricula should rely on the considerable body of existing work on the topic and the specific recommendations of the present report (section 4).
There is Hope

Well, how are you doing in kindergarten?

Just playing games and painting pictures.

Hopefully there will soon be computer science.

And Finally:

Money is not everything, but without money everything is nothing.
There is Hope

Well, how are you doing in kindergarten
Just playing games and painting pictures
Hopefully there will soon be computer science

And Finally:

Informatics
Money is not everything, but without money everything is nothing.