How to shape Computer Science Education in the AI Era?
Bridging Technology, Humanities, and Inspiring the Desire to Learn.

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University of corsica pasquale paoli

A view of Teaching:

1765 University founded by Pasquale Paoli
1981 Reopening of the university after two centuries of closure
5000 students
130 different diplomas, from baccalaureate up to doctorate level

A view of Research:

Laboratory of Environmental Sciences, UMR SPE
Multidisciplinary research
CNRS, Inserm, INRAE, CEA, Ifremer, Cirad

GREATER BASTIA
Stella Mare Marine Research Platform
Higher Education School of Teaching and Education

CARGÈSE
Institut of Scientific Studies

CORTE
University campuses and laboratories

AJACCIO
Research Center for Energy and Natural Resources
Higher Education School of Teaching and Education
Authors and context

Research team Simulation and Ubiquitous Systems (SISU), UMR CNRS SPE 6134:

- Evelyne Vittori, Associate Professor : Modelisation/Simulation
- Paul-Antoine Bisgambiglia, Associate Professor with Accreditation to Supervise Research : Modelisation/Simulation
- Marie-Laure Nivet, Associate Professor also member of Renewable Energy Team : Machine Learning – Trying to convert to Digital Ethics...

Teaching an intensive refresher course in our Bachelor’s Degree program in Computer Science

First year after democratization of ChatGPT, and all the other AI tools.
Undone...

What would be the global impact in education and more generally in society, from short to long term of tools like generative AI if they are open and accessible to all, every time they need it, even if they don’t need it?

... The study that all the major technology companies have not carried out before offering us their products.
How to shape Computer Science Education in the AI Era?
Bridging Technology, Humanities, and Inspiring the Desire to Learn.

- Things are changing with the arrival of generative AI, and there's no doubt that things will continue to change in the field of CS.
- Isn't it time to re-think CS curricula?
  - Integration of AI tools in teaching
  - Integration of AI tools in day life
  - Taking a step towards human science
Points discussed

- AI tools in CS teaching, look back to other “revolutions” in education
- Time to re-think CS curricula?
- How to go further? How to think more globally?
AI coding tools, capabilities

**Code generation**
- Specification-to-code
- Conversational specification-to-code
- Code completion
- Code refactoring
- Code simplification
- Language translation
- Test generation

**Code explanation**
- Explanations at varying expertise levels
- Debugging help
- Conversational bug finding
- Code review and critique
- Conceptual explanations with code examples

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What will change?

76% of all respondents are using or are planning to use AI tools in their development process this year. Those learning to code are more likely than professional developers to be using or use AI tools (92% vs. 70%).

Regardless of being a professional developer or someone learning to code, people believe that their development workflow will be different in a year because of AI tools.

Thinking about how your workflow and process changes over time, how similar or different do you anticipate your workflow to be 1 year from now as a result of AI tools you are currently using?
A brief look at the past...
What about the introduction of calculators in schools?

How, if at all, does this change learning and teaching mathematics?
Lessons from the introduction of calculators in mathematics teaching

“At all grades but Grade 4, a use of calculators in concert with traditional mathematics instruction apparently improves the average student's basic skills with paper and pencil, both in working exercises and in problem solving.” (Hembree and al. 1986)

But...

“However, the quasi-experimental design of many of these studies is based on the assumption that the same instructional objectives and methods are valid for both pen and paper and technology enhanced tasks.” (Goos and al. 2003)

Four metaphors for technology mediated learning (Goos and al. 2003 ; Tricot 2020):
- Technology as master: lack of comprehension
- Technology as servant: tasks are steel the same, but results are obtained more easily
- Technology as partner: explore things differently, enhance comprehension
- Technology as extension of self: explore new areas that would otherwise be unattainable

Grade 4 (CM1) acquisition of basic skills – corresponding to CS1/CS2 courses?

What are the basic skills in information science in the age of artificial intelligence?

Lessons from the introduction of calculators in mathematics teaching

« It is recommended that students **be taught more about how, when, and when not to use calculators in mathematics**, and when (and when not) to support calculator work with pen-and-paper calculations. » (Close and al. 2008)

“They still fear that their students will not learn or remember the basics or be able to think about mathematics as a logical whole as they grow older. Teachers have not wanted their students to become **dependent** on calculators.”

“All four major groups agree the calculators **increase motivation and desire to learn** among students and should be used on a regular basis” (Banks. 2011)


Look at the past...
What about internet?
The introduction of the “copy/paste” effect

How does it change learning and teaching CS?
Internet... Only 30 years of experience

“Based on findings in the field of neuroscience, it has been observed that the strength of memory is directly related to the frequency of memory retrieval”

“People with a larger knowledge base are less susceptible to the consequences of Internet use than those with a smaller knowledge base. » (Gong, al. 2024)

What about the “googling effect” transposed to AI tools?

Internet... Only 30 years of experience

“Think before you Google...

... The benefit of attempting to solve the problem before googling appeared larger with some degree of programming experience, consistent with the notion that some prior knowledge can help learners integrate new information in ways that benefit its learning as well as that of previously studied related information.”

(Giebl & al.2021)

Longitudinal studies are needed on the impact of AI tools on brain and cognition

Is it CS learning a good study case?

Saskia Giebl, Stefany Mena, Benjamin C. Storm, Elizabeth Ligon Bjork and, Robert A. Bjork, 2021. Answer First or Google First? Using the Internet in ways that Enhance, not Impair, One’s Subsequent Retention of Needed Information Vol. 20(1) 58-75. https://doi.org/10.1177/1475725720961593
AI coding tools, limitations

Inaccuracies, hallucination
Code quality
Knowledge cutoff
Learning curve: Novices may have a hard time producing high-quality results
Nondeterminism: reproducibility crisis?
Offensive content
Ethical objections: ecological impact, copyright, shadow workers, self-esteem, addiction?...

As teachers, we think that AI tools hallucinations can be beneficial.

It’s an educational asset
For the moment students must be able to understand the answer before using it...
They must develop their critical mind
It looks like a “copy-paste++”
But...

What if, AI tools became, more and more reliable? What if they could produce a 'perfect' proposal - let's say a program perfectly adapted - to a given question/criteria?

Who will guarantee/define the “perfectness”? 
What will be the impact in the short, medium and long term of cohabiting with a knowing-entity?

How do you keep the desire to learn when you think you already have the power to know everything you need, when you need it?
“Why is it worth learning details—or anything at all—if the knowledge is available from the Internet within seconds?”

“We learn by storing pieces of knowledge in our long-term memory and forming connections between them. If the knowledge is not present in the brain, because you have not yet learned it well, the brain cannot form any connections between it, so higher levels of understanding and abstraction are not possible.”

Understand that learning, memorizing and real understanding are necessary to be creative...

Risks of inequality: Good students will quickly and easily understand that they need to think for themselves... But what about the others? Who benefits?
But...
We have no time, no place in CS curricula...
What changes are we going to make?

What will be the aspects of CS that will be more impacted by Generative AI, driving us to reduce their teaching, letting time to other knowledges?
If it is the end of « classical » programming...
What is this the beginning of?

« In the future, CS students are not going to need to learn such mundane skills as how to add a node to a binary tree or code in C++. [...] 

The new atomic unit of computation becomes not a processor, memory, and I/O system implementing a von Neumann machine, but rather a massive, pre-trained, highly adaptive AI model. »

CS2023 Knowledge Model

Knowledge areas: The CS2023 knowledge model consists of 17 knowledge areas, listed in alphabetical order of their abbreviation:

- Artificial Intelligence (AI)
- Algorithmic Foundations (AL)
- Architecture and Organization (AR)
- Data Management (DM)
- Foundations of Programming Languages (FPL)
- Graphics and Interactive Techniques (GIT)
- Human-Computer Interaction (HCI)
- Mathematical and Statistical Foundations (MSF)
- Networking and Communication (NC)
- Operating Systems (OS)
- Parallel and Distributed Computing (PDC)
- Software Development Fundamentals (SDF)
- Software Engineering (SE)
- Security (SEC)
- Society, Ethics, and the Profession (SEP)
- Systems Fundamentals (SF)
- Specialized Platform Development (SPD)

Generative AI, like other emerging technologies, has the potential to revolutionize computer science education. It will impact course content, pedagogy and assessment techniques. Harnessing generative AI in service of the goals of formal education will be one of the most significant challenges for the community over the next few years.

Where and how to promote “within limit” and “for good”? 
Given the pervasiveness of computing applications, a computing solution is not just technical in nature. It must incorporate issues related to the society, ethics, and the profession as well. Interweaving these issues into technical coverage so as to make them unavoidable in a curriculum is a challenge every educator must take up in fulfillment of responsible citizenry.

In CS2023, issues of the society, ethics, and the profession (SEP) have been explicitly enumerated in as many knowledge areas as possible to highlight their importance across the curriculum and help educators incorporate them into their courses. Curricular practice articles have also been included on responsible computing, ethics, and CS for good.

++ Must be addressed in ALL CS domain ++
Not just, one time, in one course...
Computer Science Curricula 2023
The Final Report

January 2024
Version 2024-01-18

The Joint Task Force on Computing Curricula
Association for Computing Machinery (ACM)
IEEE-Computer Society (IEEE-CS)
Association for the Advancement of Artificial Intelligence (AAAI)

Society, Ethics and Professionalism (SEP)

<table>
<thead>
<tr>
<th>Knowledge Units</th>
<th>CS Core</th>
<th>KA Core</th>
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<tbody>
<tr>
<td>Social Context</td>
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<td>2</td>
</tr>
<tr>
<td>Methods for Ethical Analysis</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Professional Ethics</td>
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<td>2</td>
</tr>
<tr>
<td>Intellectual Property</td>
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<td>1</td>
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<tr>
<td>Privacy and Civil Liberties</td>
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<td>1</td>
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<td>Communication</td>
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<td>1</td>
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<tr>
<td>Sustainability</td>
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<td>1</td>
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<tr>
<td>History</td>
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<tr>
<td>Economies of Computing</td>
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<td>1</td>
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<tr>
<td>Security Policies, Laws and Computer Crimes</td>
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<td>1</td>
</tr>
<tr>
<td>Equity, Diversity and Inclusion</td>
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<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
<td><strong>14</strong></td>
</tr>
</tbody>
</table>

Table 3.1: Comparative weight of computing topics across the five kinds of degree programs

<table>
<thead>
<tr>
<th>Knowledge Area</th>
<th>CE min</th>
<th>CE max</th>
<th>CS min</th>
<th>CS max</th>
<th>IS min</th>
<th>IS max</th>
<th>IT min</th>
<th>IT max</th>
<th>SE min</th>
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<tbody>
<tr>
<td>Legal / Professional / Ethics / Society</td>
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<td>2</td>
<td>4</td>
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<td>5</td>
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<td>3</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Analysis of Business Requirements</td>
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<td>5</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>
What about Human in CS2023 proposal?

Human vulnerabilities?
Nudges, addictive comportments, manipulation

« because computing as a discipline is becoming progressively more entangled within the human and social lifeworld, computing as an academic discipline must move away from engineering-inspired curricular models and integrate the analytic lenses supplied by social science theories and methodologies. »

Randy Connolly
Deep comprehension of Human is needed

Addiction problems: “They must resist...”
AI predictive assistant: It’s just an information, it’s not the truth, the expert is steel the expert...
Uses of nudges: No one forces them to do anything they don’t want to do
Dark patterns: It’s a business model problem...
Pervasive and persuasive technology?
One more time... go back

« Students also need to develop the ability to ask serious questions about the social impact of computing and to evaluate proposed answers to those questions. Future practitioners must be able to anticipate the impact of introducing a given product into a given environment. Will that product enhance or degrade the quality of life? What will the impact be upon individuals, groups, and institutions? »


Implementation seems to be taking time...
What we are calling for

- What and how to teach CS for future students?
  - Introduce more Human in CS

- How to inspire the desire to learn to our CS students in the era of generative AI?
  - Metacognition, explain them how their brain learn
  - Test the ability of students to delay gratification (marshmallow test) and the long-term effect - social sciences methodologies needed

- What will be the impact of living along with a knowing entity for CS students, for learner, for all the others?
  - Longitudinal research must be made and support in a multidisciplinary way: neurosciences, CS, educational sciences

- Computer Sciences teacher’s responsibilities in front of CS students?
  - Social: Give them some key to understand human are thinking, and what are their weaknesses and bias
  - CS: Center for Human Technology

- Computer Sciences teacher’s responsibilities in front of Society?
  - We have to make CS aware of the Human vulnerabilities and the complexity of human nature as well as the complexity of living things
Go back to the first missions of Universities?

« It is committed to the public good, to democracy and human rights, and to basing policies and decisions on facts established through study, research and critical reflection – as well as to challenging received wisdom based on new discoveries. »

The Democratic mission of Higher Education

“before students can help change the world, they need to understand it”

...before CS students can help people and society using tech, they need to understand people and society!
Undone...

What would society be like if computing science had been/was classified as a human science?
Computer Science Curricula 2023
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Alternative
The Joint Task Force on Computing Curricula
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within limits and for good...
Thank you!

Questions?

Share?