

How to shape Computer Science Education in the AI Era?

Bridging Technology, Humanities, and Inspiring the Desire to Learn.

Marie-Laure Nivet, Evelyne Vittori, Paul-Antoine Bisgambiglia

nivet_m@univ-corse.fr, vittori_e, bisgambiglia_pa

University of Corsica, UMR SPE 6134 - SISU



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



CARGÈSE
Institut of
Scientific
Studies

AJACCIO
Research Center
for Energy and Natural
Resources

Higher Education
School of Teaching
and Education

CORTE
University
campuses and
laboratories

GREATER BASTIA
Stella Mare Marine
Research Platform

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 Bigambiglia, 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-thing 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

...

Sam Lau and Philip J. Guo. 2023. From "Ban It Till We Understand It" to "Resistance is Futile": How University Programming Instructors Plan to Adapt as More Students Use AI Code Generation and Explanation Tools such as ChatGPT and GitHub Copilot. In Proceedings of the 2023 ACM Conference on International Computing Education Research V.1 (ICER '23 V1), August 07–11, 2023, Chicago, <https://doi.org/10.1145/3568813.3600138>

Code explanation

Explanations at varying expertise levels

Debugging help

Conversational bug finding

Code review and critique

Conceptual explanations with code examples



2023 Developer Survey

In May 2023 over 90,000 developers responded to our annual survey about how they learn and level up, which tools they're using, and which ones they want.

<https://survey.stackoverflow.co/2023/#ai>

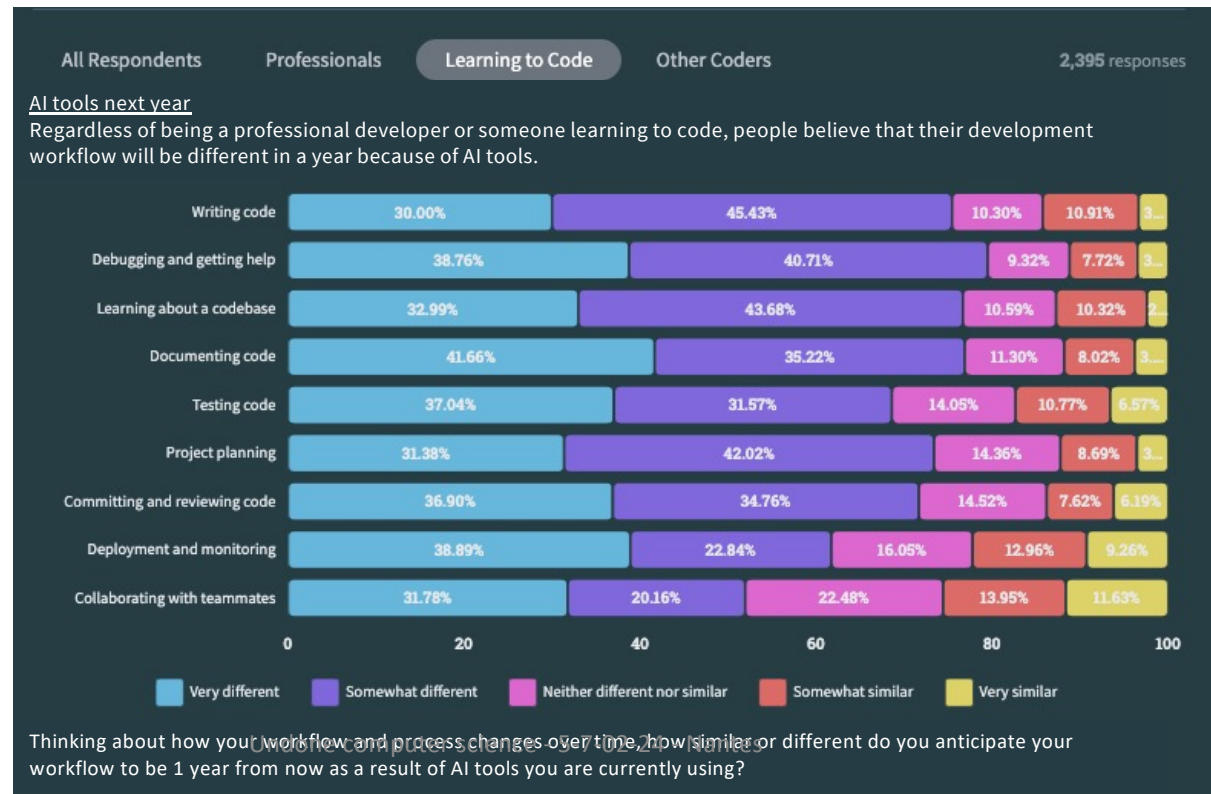


AI Sentiment and usage

70% 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 (82% vs. 70%).

AI tools in the development process →

What will change?



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...

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

“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)

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

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

Are these metaphors relevant for CS teaching in AI era?

Hembree, R., Dessart, D.J., 1986. Effects of Hand-Held Calculators in Precollege Mathematics Education: A Meta-Analysis. Journal for Research in Mathematics Education 17, 83–99. <https://doi.org/10.5951/jresmetheduc.17.2.0083>

Goos, M., Galbraith, P., Renshaw, P., Geiger, V., 2003. Perspectives on technology mediated learning in secondary school mathematics classrooms. The Journal of Mathematical Behavior 22, 73–89. [https://doi.org/10.1016/S0732-3123\(03\)00005-1](https://doi.org/10.1016/S0732-3123(03)00005-1)

Tricot, A., 2020. Quelles fonctions pédagogiques bénéficient des apports du numérique ? Paris : Cnesco.

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)

How, when, and when not to use AI tools in CS?

“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.”

How to use AI tools as partner, to enhance creativity and avoid AI tools acting as Master ?

“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)

Could it be a way to develop appetite for CS?

Close, S., E. Oldham, P. Surgenor, G. Shiel, T. Dooley, and M. O’Leary. 2008. “The Effects of Calculator Use on Mathematics in Schools and in Certificate Examinations,” Final report on phase 2. Dublin: St. Patrick’s College, Trinity College and Educational Research Centre.

http://www.erc.ie/documents/calculator_final_report_phase2.pdf.

Banks, S., 2011. A Historical Analysis of Attitudes Toward the Use of Calculators in Junior High and High School Math Classrooms in the United States Since 1975. Cedarville University. <https://doi.org/10.15385/tmed.2011.1>

London computer science - 5-7-02-24 - Nantes

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?

Gong, C., Yang, Y., 2024. Google effects on memory: a meta-analytical review of the media effects of intensive Internet search behavior. Front Public Health 12, 1332030. <https://doi.org/10.3389/fpubh.2024.1332030>

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?

AI coding tools, limitations

Inaccuracies, hallucination

Code quality

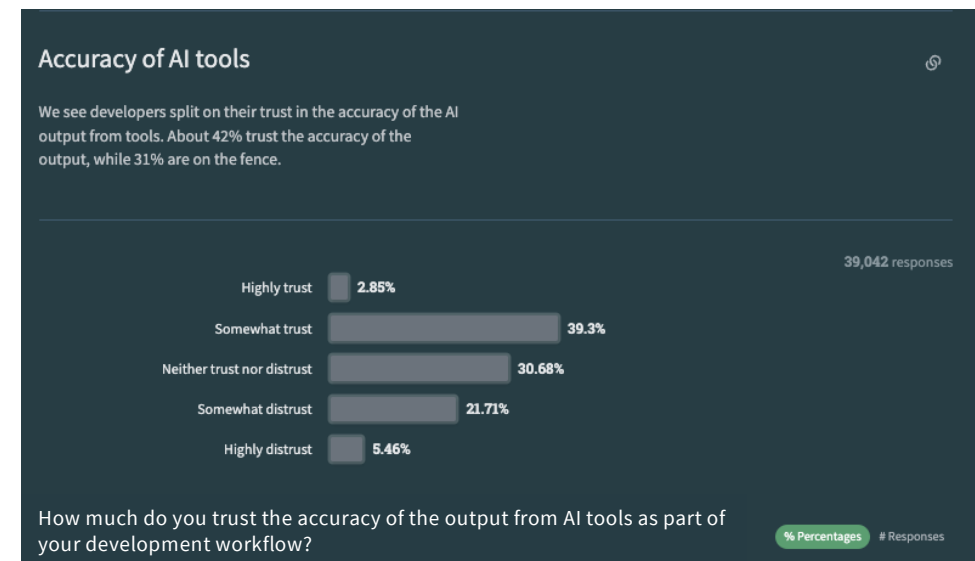
Knowledge cutoff

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?...



Sam Lau and Philip J. Guo. 2023. From "Ban It Till We Understand It" to "Resistance is Futile": How University Programming Instructors Plan to Adapt as More Students Use AI Code Generation and Explanation Tools such as ChatGPT and GitHub Copilot. In Proceedings of the 2023 ACM Conference on International Computing Education Research V.1 (ICER '23 V1), August 07–11, 2023, Chicago, <https://doi.org/10.1145/3568813.3600138>

As teachers, we think that AI tools hallucinations can be benefic

It's an educational asset

For the moment students must be able to understand the answer before using it...

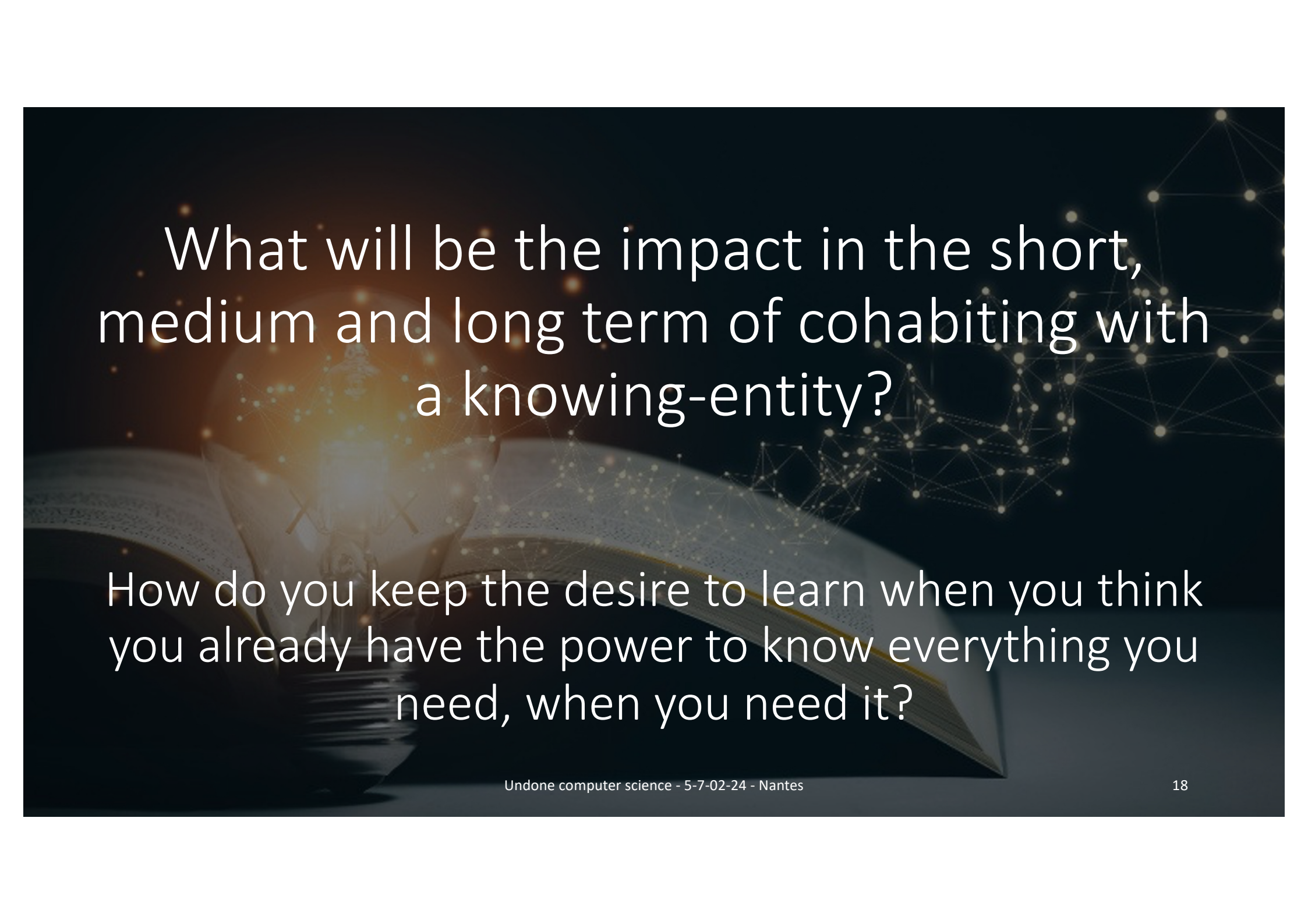
They must develop their critical mind

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.”

Brown, N.C.C., Hermans, F.F.J., Margulieux, L.E., 2024. 10 Things Software Developers Should Learn about Learning. *Commun. ACM* 67, 78–87. <https://doi.org/10.1145/3584859>

Undone computer science - 5-7-02-24 - Nantes

research



DOI:10.1145/3584859

Understanding how human memory and learning works, the differences between beginners and experts, and practical steps developers can take to improve their learning, training, and recruitment.

BY NEIL C.C. BROWN, FELIENNE F.J. HERMANS,
AND LAUREN E. MARGULIEUX

10 Things Software Developers Should Learn about Learning

LEARNING IS NECESSARY for software developers. Change is perpetual: New technologies are frequently invented, and old technologies are repeatedly updated. Thus, developers do not learn to program just once—over the course of their careers they will learn many new programming languages and frameworks.

Just because we learn does not mean we understand how we learn. One survey in the U.S. found that the majority of beliefs about memory were contrary to those of scientific consensus: People do not intuitively understand how memory and learning work.³⁷

As an example, consider learning styles. Advocates of learning styles claim that effective instruction matches learners' preferred styles—visual learners look, auditory learners listen, and kinesthetic learners do. A 2020 review found that 89% of people believe that learners' preferred styles should dictate instruction, though researchers have known for several decades that this is inaccurate.³⁸ While learners have preferred styles, effective instruction matches the content, not learning styles. A science class should use graphs to present data rather than verbal descriptions, regardless of visual or auditory learning styles, just like cooking classes should use hands-on practices rather than reading, whether learners prefer a kinesthetic style or not.

Decades of research into cognitive psychology, education, and programming education provide strong insights into how we learn. The next 10 sections of this article provide research-backed findings about learning that apply to software developers and discuss their practical implications. This information can help with learning for yourself, teaching junior staff, and recruiting staff.

1. Human Memory Is Not Made of Bits

Human memory is central to learning. As Kirschner and Hendrick put it, “Learning means that there has been a change made in one's long-term memory.”³⁹ Software developers are familiar with the incredible power of computer memory, where we can

» key insights

- Learning is vital for programmers, but the human mind works quite differently than a computer.
- Understanding how humans learn can help you learn more effectively.
- The Internet and LLMs have not made learning obsolete; learning is essential and takes time.
- Expertise changes how you think, letting you solve problems more easily but also potentially hindering your ability to teach.

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. »

Welsh, M., 2023. The End of Programming. Commun. ACM 66, 34–35.
<https://doi.org/10.1145/3570220>

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)



<https://csed.acm.org/>

CS2023 Knowledge Model

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

- | | |
|---|---|
| <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • 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”?

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)



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)



2005

Knowledge Area	CE		CS		IS		IT		SE	
	min	max	min	max	min	max	min	max	min	max
Legal / Professional / Ethics / Society	2	5	2	4	2	5	2	4	2	5
Information Systems Development	0	2	0	2	5	5	1	3	2	4
Analysis of Business Requirements	0	1	0	1	5	5	1	2	1	3
E-business	0	0	0	0	4	5	1	2	0	3

Society, Ethics and Professionalism (SEP)

Knowledge Units	CS Core	KA Core
Social Context	3	2
Methods for Ethical Analysis	2	1
Professional Ethics	2	2
Intellectual Property	1	1
Privacy and Civil Liberties	2	1
Communication	2	1
Sustainability	1	1
History	1	1
Economies of Computing	0	1
Security Policies, Laws and Computer Crimes	2	1
Equity, Diversity and Inclusion	2	2
Total	18	14

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

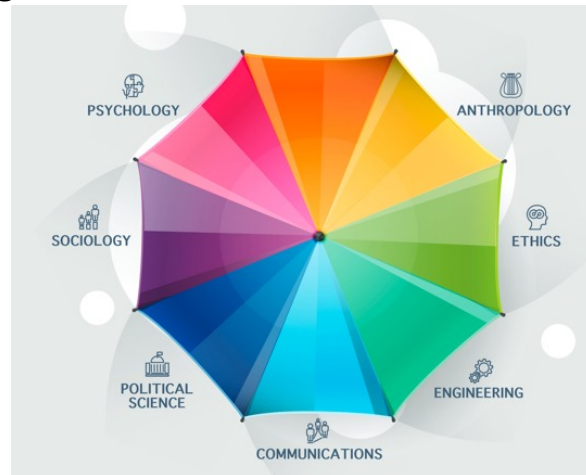
What about Human in CS2023 proposal?

Human vulnerabilities?

Nudges, addictive compartments, 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



contributed articles



DOI:10.1145/3383444

Fully appreciating the overarching scope of CS requires weaving more than ethics into the reigning curricula.

BY RANDY CONNOLLY

Why Computing Belongs Within the Social Sciences

ON OCTOBER 23, 2008, Alan Greenspan, the Chair of the U.S. Federal Reserve, was testifying before Congress in the immediate aftermath of the September 2008 financial crash. Undoubtedly the high point of the proceedings occurred when Representative Henry Waxman pressed the Chair to admit “that your view of the world, your ideology, was not right,” to which Greenspan admitted “Absolutely, precisely.”¹⁷ Fast forward 10 years to another famous *mea culpa* moment in front of Congress, that of Mark Zuckerberg on April 11, 2018. In light of both the Cambridge

Analytica scandal and revelations of Russian interference in the 2016 U.S. election, Zuckerberg also admitted to wrong: “It’s clear now that we didn’t do enough to prevent these tools from being used for harm. That goes for fake news, foreign interference in elections, and hate speech, as well as developers and data privacy.”¹⁵

As far as *mea culpas* go, Greenspan’s was considerably more concise, but also much more insightful as to the root problem. Greenspan admitted the problem was not due to misguided user expectations, or to poorly worded license agreements, or to rogue developers. Instead he recognized the problem lay in a worldview that seemed to work for a while ... until it didn’t. In the immediate aftermath of the financial crisis, there were calls for reforms, not only of the financial services industry, but also within universities, where it was thought that unrealistic models and assumptions within economics departments²⁰ and business schools²¹ were also responsible for inculcating a worldview that led to the crisis. It is time for us in computing departments to do some comparable soul searching.

This article is one attempt at this task. It argues the well-publicized social ills of computing will not go away simply by integrating ethics instruction or codes of conduct into computing curricula. The remedy to these ills

» key insights

- The social ills of computing will not go away simply by integrating more ethics instruction or codes of conduct into computing curricula.
- A better approach to addressing these problems would be to move the academic discipline of computing away from engineering-inspired curricular models and supplement it with the methods, theories, and perspectives of the social sciences.
- In practice, computing is already moving tentatively into the methodological and theoretical pluralism of the social sciences, but this movement has not been fully recognized within academic computing.

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 still 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? »

in ACM/IEEE-CS Joint Curriculum Task Force, Computing Curricula 1991 (1991), ACM Press and IEEE Computer Society Press.

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

Bergan, S., Gallagher, T., Harkavy, I.R., Europarat (Eds.), 2020. Academic freedom, institutional autonomy and the future of democracy, Council of Europe higher education series. Presented at the Global forum on academic freedom, institutional autonomy and the future of democracy, Council of Europe, Strasbourg.

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

college.harvard.edu/academics/liberal-arts-sciences

...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?

Must be done...

Computer Science

~~Curricula 2023~~ within limits
and for good...

The Final Report

~~January 2024~~

Alternative

~~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)~~

Thank you!

Questions?
Share?



UNIVERSITÀ
DI CORSICA

PASQUALE
PAOLI

www.universita.corsica



Production: communication service of the university of corsica – 2023