Reprogramming Computer Science Education for a Sustainable Future

Prepared for "Sustainability in Computer Science" Lecture Series, Austria, 2026

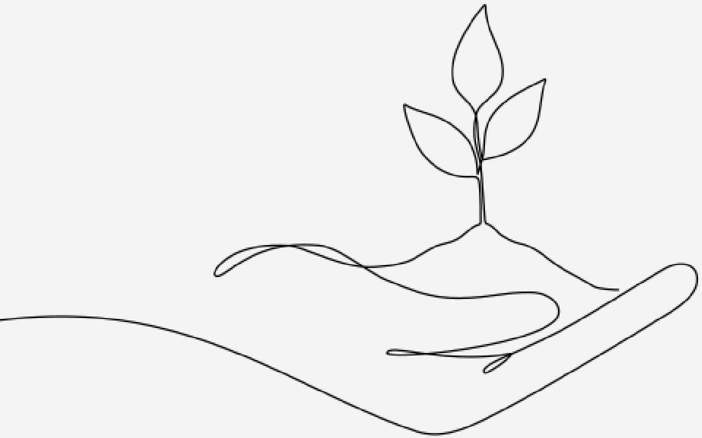
Univ. Prof. Dr. Michaela Zint, MBA

School for Environment and Sustainability

College of Literature, Science & the Arts)

School of Education

University of Michigan

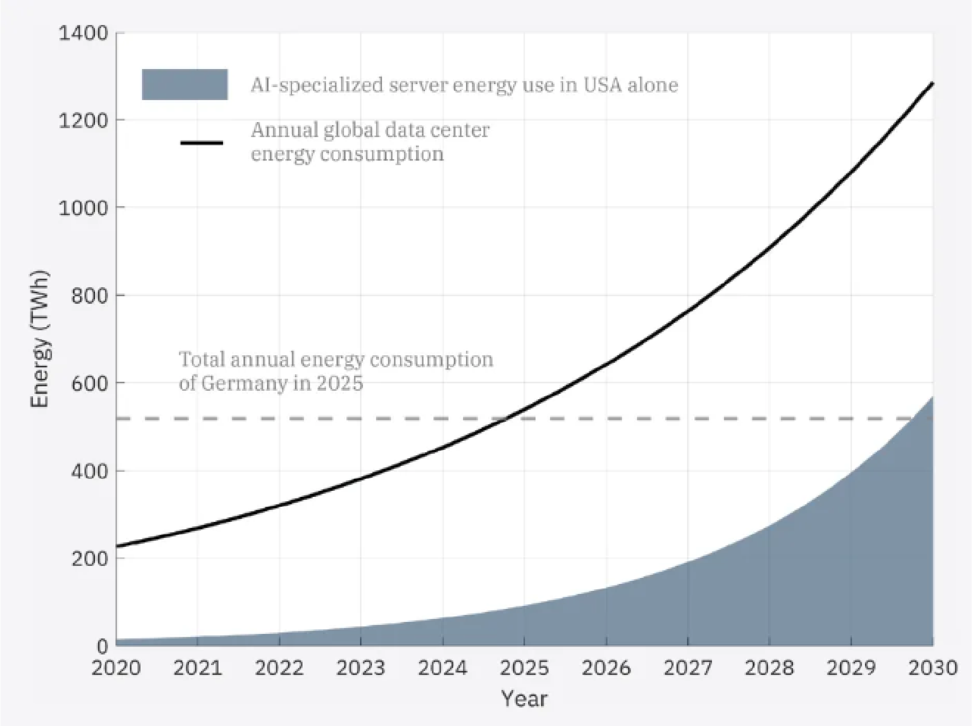


Sustainability

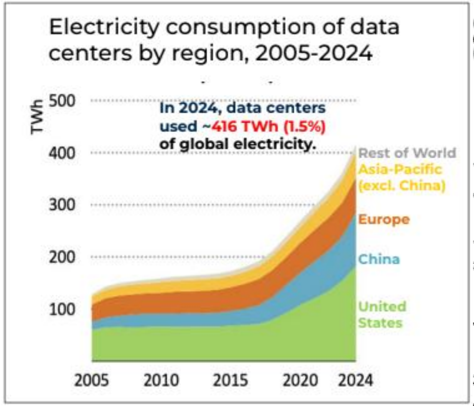
Source: Zint, TU Wien (2022) inspired by Sustainable Development Goals,, Planetary Boundaries, Doughnut Economics

Why am I ***interested*** in sustainability & computer science?

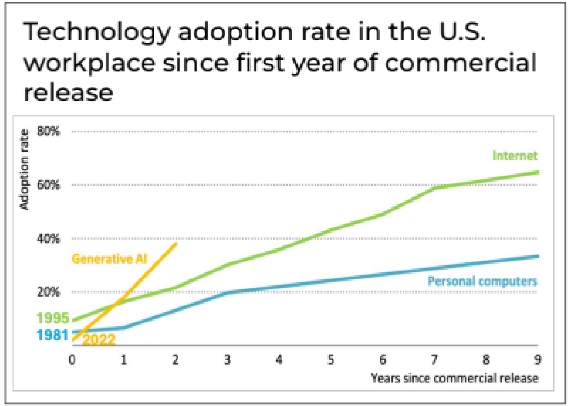
Share of AI in Data Center Energy Consumption (estimated from IEA and LBNL data)[18,19,20]



Source: https://css.umich.edu/publications/factsheets/built-environment/artificial-intelligence-factsheet



International Energy Agency (IEA) Energy and AI Report, April 2025
https://www.iea.org/reports/energy-and-ai



IEA Energy and AI Report, April 2025
https://www.iea.org/reports/energy-and-ai

How Computing Professionals Shape — and Are Shaped by — Sustainability

Illustrative examples from Austria's Sustainability Lecture Series

Sustainability Dimension	Computing as Part of the Solution	Computing as Part of the Problem
Climate risk & response	Real-time sensing of fires & floods *(Aral, Nastic)*	AI model training emitting large CO_2 footprints *(Brandic, Nastic)*
Energy systems	Smart meters reducing household energy use *(Elmenreich)*	Data centers consuming grid-scale electricity *(Brandic)*
Materials & production	Simulations replacing physical prototyping *(Brandic)*	Manufacturing accounting for ~80% of device energy *(Mayerhofer)*
Digital infrastructure	Distributed sensing & edge computing *(Nastic)*	Blockchains using national-scale power *(Mayerhofer, Pietrzak)*

How Computing Professionals Shape — and Are Shaped by — Sustainability

Illustrative examples from the University of Michigan (U-M)

Sustainability Challenge	U-M Researcher(s)	Example Contribution	Role of Computing
Energy-efficient AI	Chung/Chowdhury	Tool to compare energy efficiency of large language models; reducing energy bloat in training	Solution enabler
Environmental health	Colacino	AI-based machine vision to analyze cellular reponses to environmental pollutants	Solution enabler
Wildfire risk & infrastructure	Jeffers, A	AI enabled analysis of wildfire behavior and infrastructure vulnerability	Solution enabler
Life Cycle impacts of AI	Miller, S.	Life Cycle assessment of AI, data centers, digital systems	Both
Data centers & governance	Mills, S	Guide for local governments re Data centers	Both
Algorithmic bias	Sandvig	When algorithm itself is racist	Problem driver
Flooding	Zhang	AI for flood prediction	Solution enabler

Research on sustainability in computing education

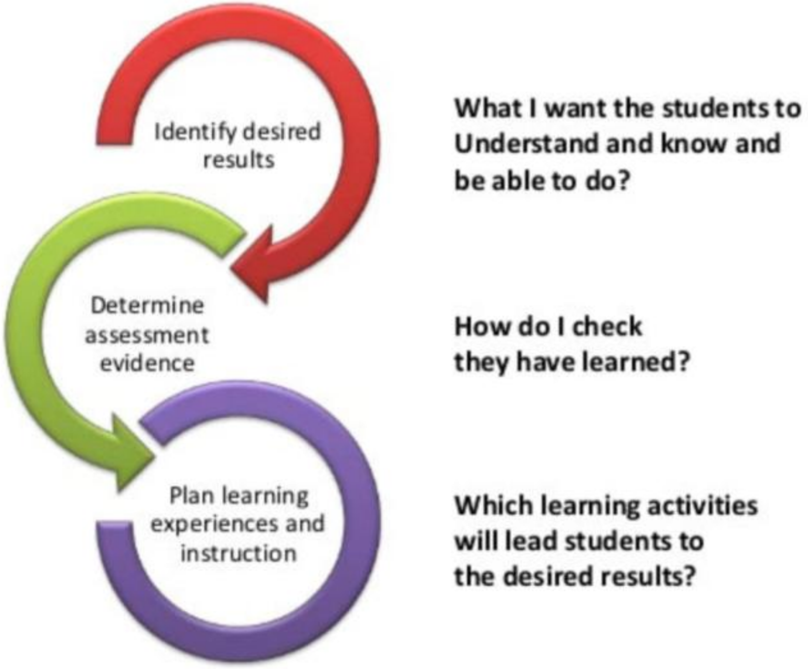
Fig. 2. The selected publications per year.

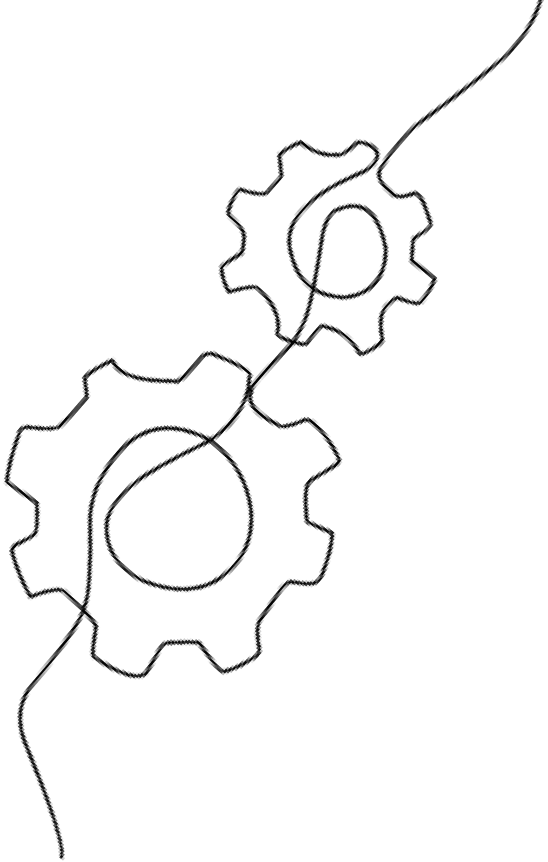
Review of 88 studies suggests:

- Most efforts focus on incremental curriculum changes
- Education is typically framed as training, not transformation
- Key gaps remain around systems thinking, values, and agency

Peters et al. (2022)

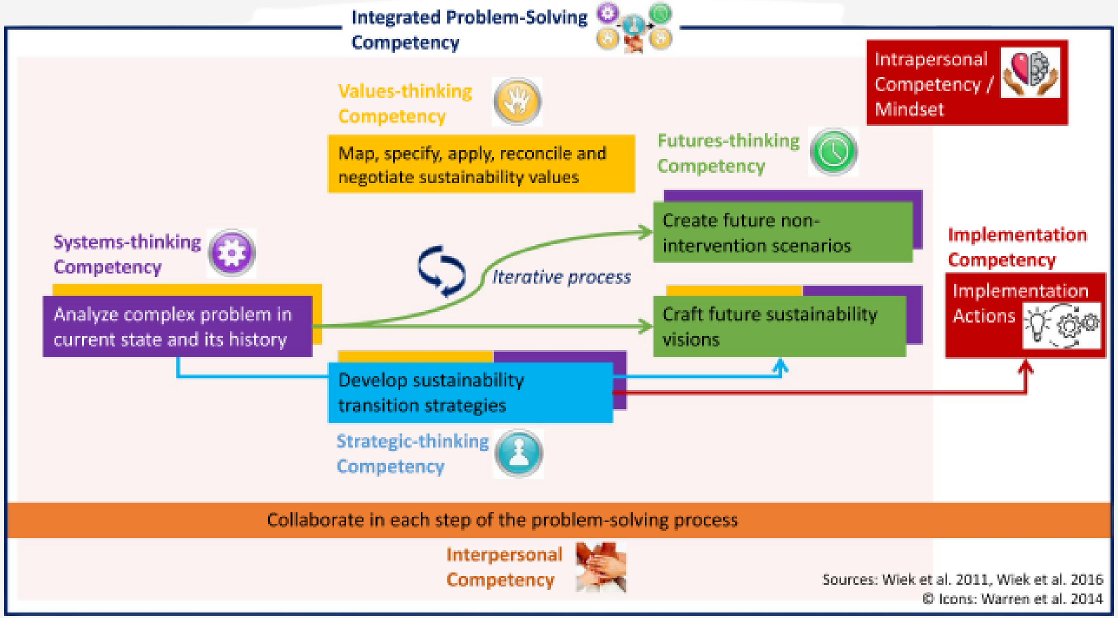
The ***Backward Design*** Process



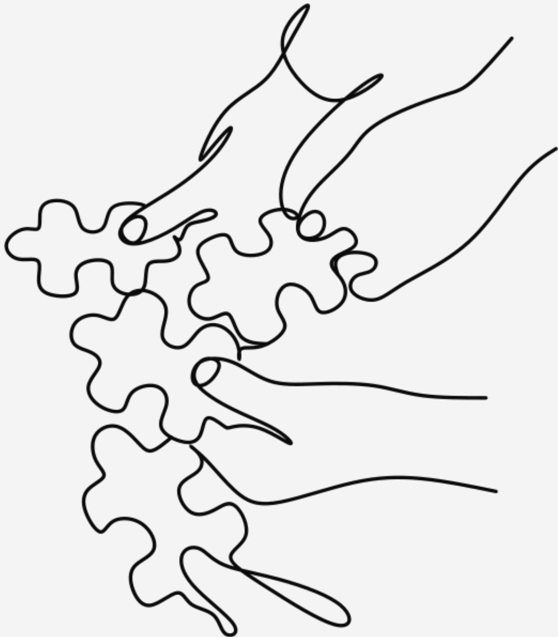


Source:https://instructionaldesignthatworks.com/2022/05/02/backwards-design-and-transparency-at-the-course-level/

Sustainability Competencies for ***Students in Higher Education***

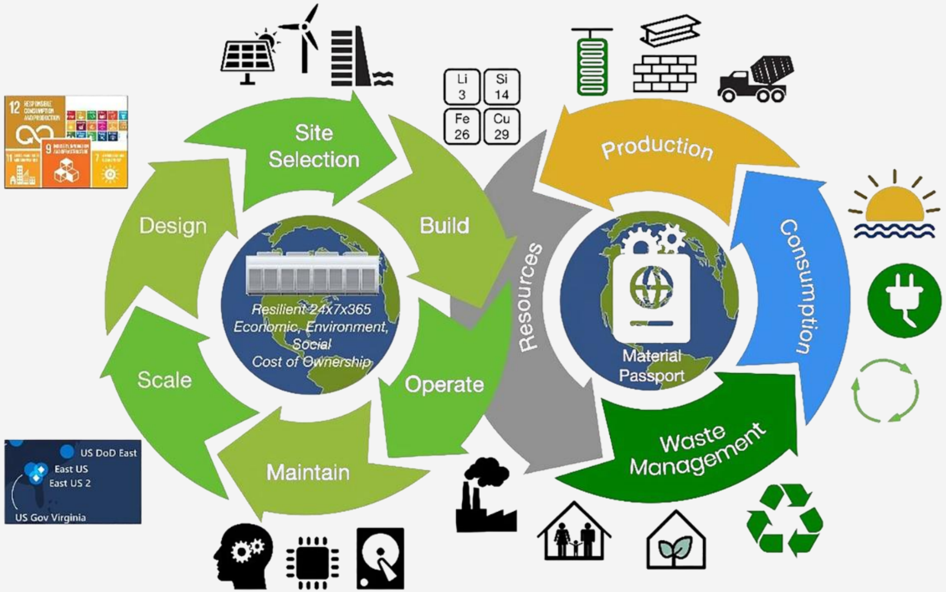


Source: Brundiers, K., Barth, M., Cebrián, G., Cohen, M., Diaz, L., Doucette-Remington, S., Dripps, W., Habron, G., Harré, N., Jarchow, M., Losch, K., Michel, J. O., Mochizuki, Y., Rieckmann, M., Parnell, R., Walker, K., & Zint, M. (2022). Key competencies in sustainability in higher education—Toward an agreed-upon reference framework. Sustainability Science, 16(1): 13–29



Systems Thinking Competence

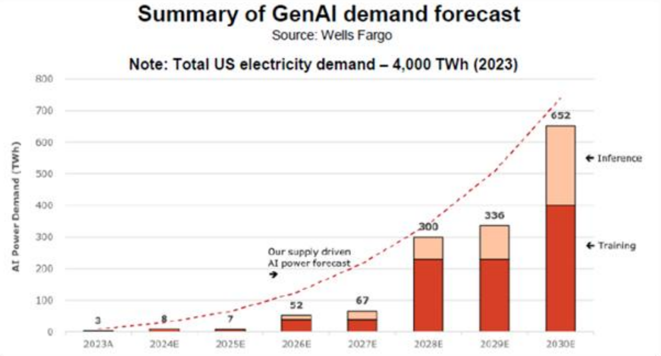
= Understanding computing as part of interconnected socio-technical and ecological systems, including feedbacks, trade offs, and unintended consequences.



Source: https://link.springer.com/article/10.1007/s43615-022-00191-9/figures/4

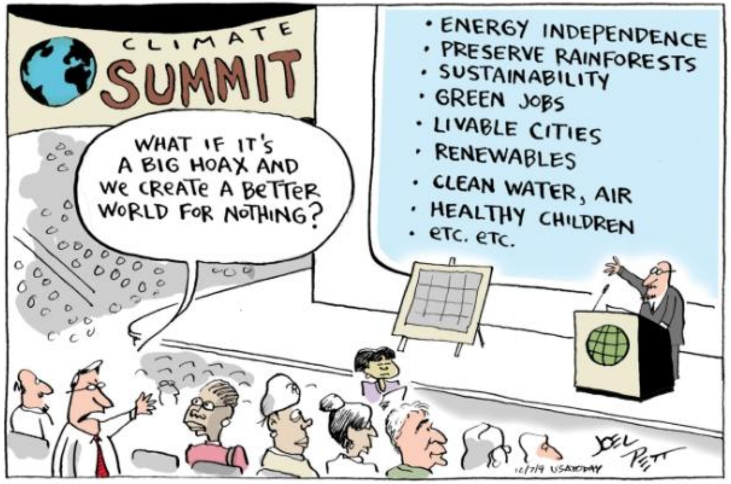
Future (Anticipatory) Thinking Competence

= Reasoning about how computing choices shape possible, probable, and desirable futures under uncertainty.



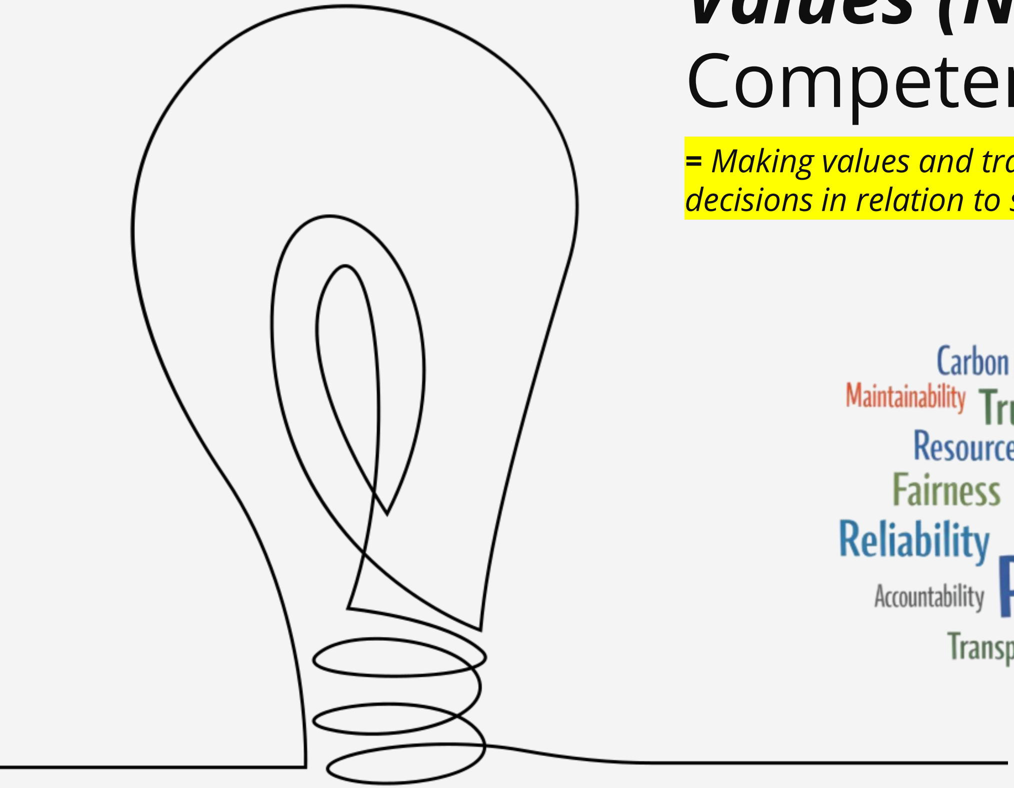
	2023A	2024E	2025E	2026E	2027E	2028E	2029E	2030E
(+) Training power demand (TWh)	3	8	7	40	40	229	229	402
(+) Inference power demand (TWh)	0	0	0	12	27	70	107	250
Demand driven AI power forecast (TWh)	**3**	**8**	**7**	**52**	**67**	**300**	**336**	**652**
Supply driven AI power forecast (TWh)	*9*	*29*	*65*	*125*	*217*	*341*	*508*	*739*

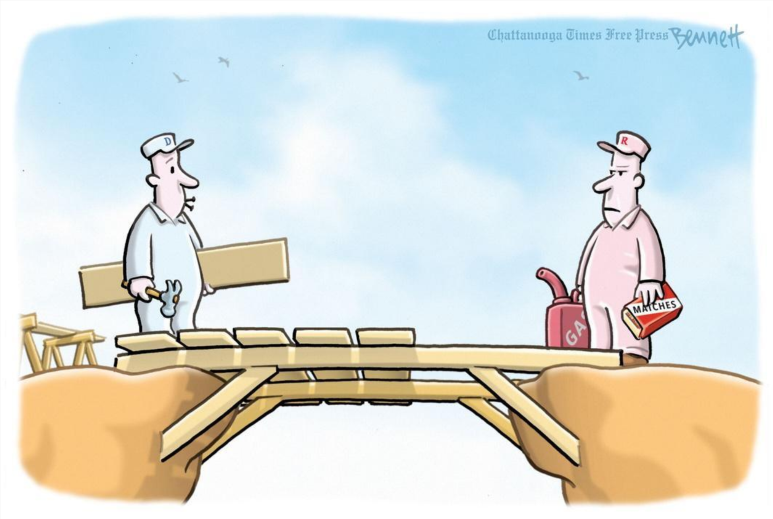
Source: Wells Fargo Securities, LLC estimates



Values (Normative) Thinking Competence

= *Making values and tradeoffs in computing design explicit, and justifying decisions in relation to sustainability goals.*

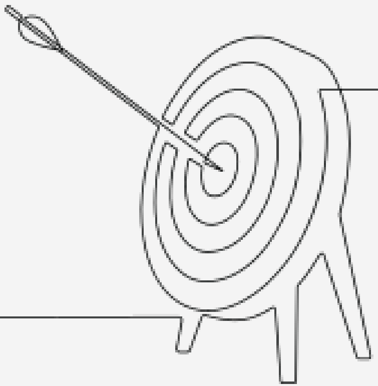


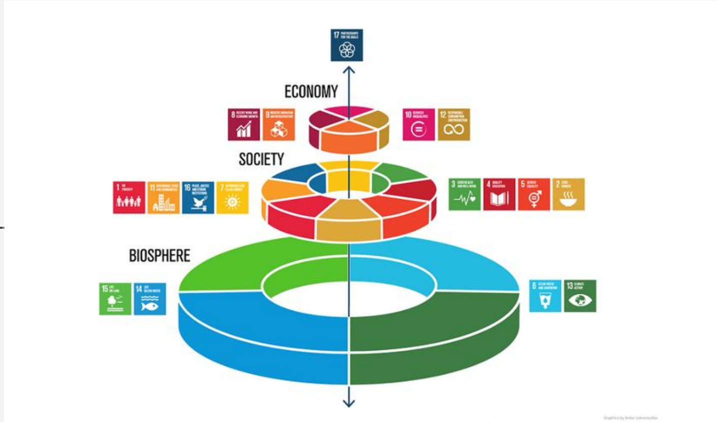


Source: https://www.cartoonstock.com/cartoon?searchID=EC189345

Strategic Thinking Competence

= Collaborating across disciplines, roles, and perspectives to address sustainability challenges through computing.





The SDGs can be linked together economically, societally and ecologically.
Illustration: J. Lokrantz/Azote

Interpersonal Competence

= Collaborating across disciplines, roles, and perspectives to address sustainability challenges through computing.

Source: C. P. Gomes (2011)

The Climate Emotions Wheel

Source: Pihkala (2002)

Image: https://www.positive.news/society/the-visual-tool-for-better-understanding-our-feelings-around-the-climate/

Intrapersonal Competence

= *Reflecting on one's role, values, emotions, and responsibility as a computing professional working on sustainability challenges.*

Five Practices	Ten Commitments
1. Model the Way	Clarify values
	Set the example
2. Inspire a Shared Vision	Envision the future
	Enlist others
3. Challenge the Process	Search for opportunities
	Experiment and take risks
4. Enable Others to Act	Foster collaboration
	Strengthen others
5. Encourage the Heart	Recognise contributions
	Celebrate the values and victories

Source: The Leadership Challenge (2012) by James Kouzes and Barry Posner

Leading Change in Computing & Sustainability Education

01

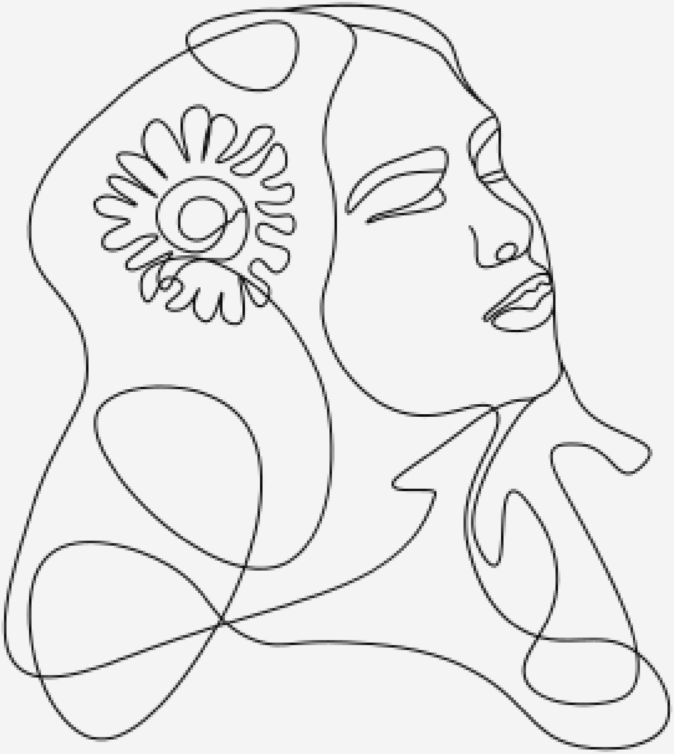
How can ***students*** lead?

E.g. University of California, Berkeley (CS / EECS)

Students lead when they shape what counts as “real” computing work

- CS students normalized climate- and sustainability-focused capstone projects
- Project choices and peer norms signaled professional relevance
- Sustainability became expected in advanced computing work

02



How can ***instructors*** lead?

Georgia Institute of Technology (Computer Science)

Faculty lead by redefining what belongs in core computer science

- Sustainability was embedded in required CS courses
- Treated as a technical design constraint, not an add-on topic
- Assignments surfaced system-level impacts and tradeoffs

Source: Alarvala et al. (2025)

03

How can ***staff*** lead?

E.g. University of Cambridge (Research Computing & IT)

Staff lead by building systems that make sustainable computing possible

- Research-computing staff made energy and carbon impacts visible
- Tools and guidance enabled lower-carbon computing choices
- Faculty and students could act because infrastructure supported them

04

How can ***administrators*** lead?

E.g. ETH Zurich (Computer Science & Engineering

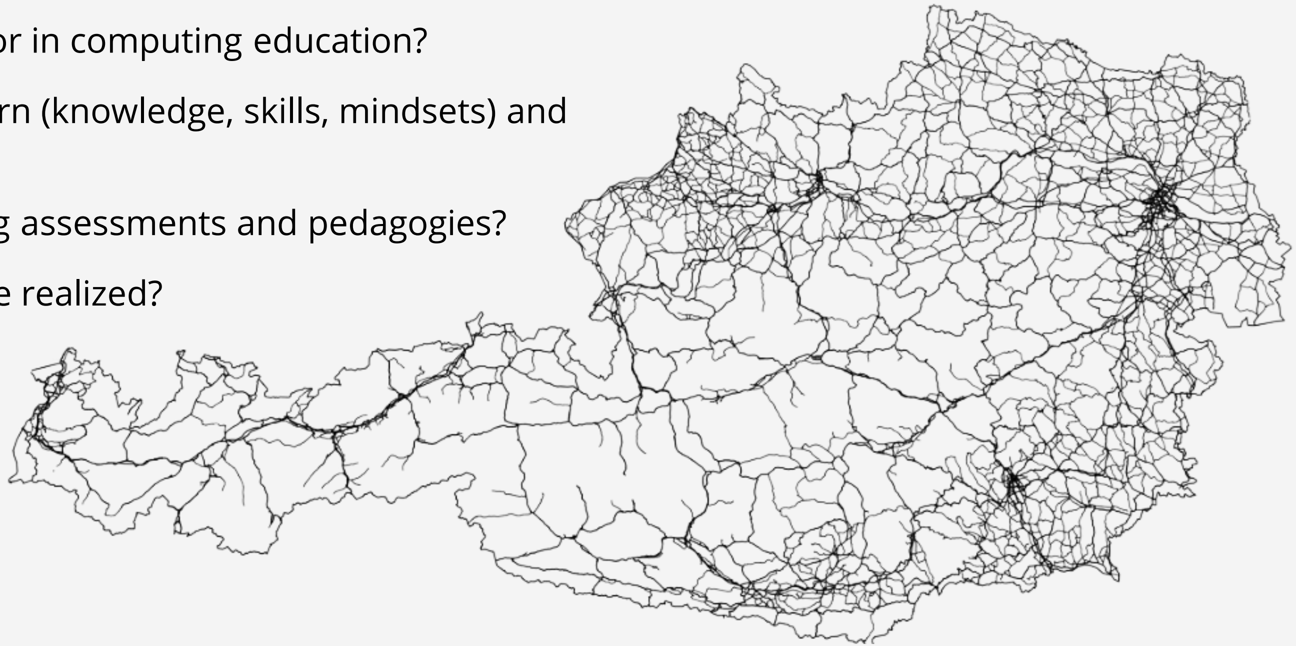
Administrators led by aligning vision, structure, and incentives

- Sustainability was framed as part of technical excellence
- Computing education aligned with institutional sustainability goals
- Resources and incentives reinforced the vision

Reprogramming Computer Science Education in ***Austria***

If sustainability were treated as core:

- What would count as rigor in computing education?
- What would students learn (knowledge, skills, mindsets) and how would they act?
- What would be promising assessments and pedagogies?
- How could your vision be realized?



Thank You!

Michaela Zint, *zintmich@umich.edu*

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