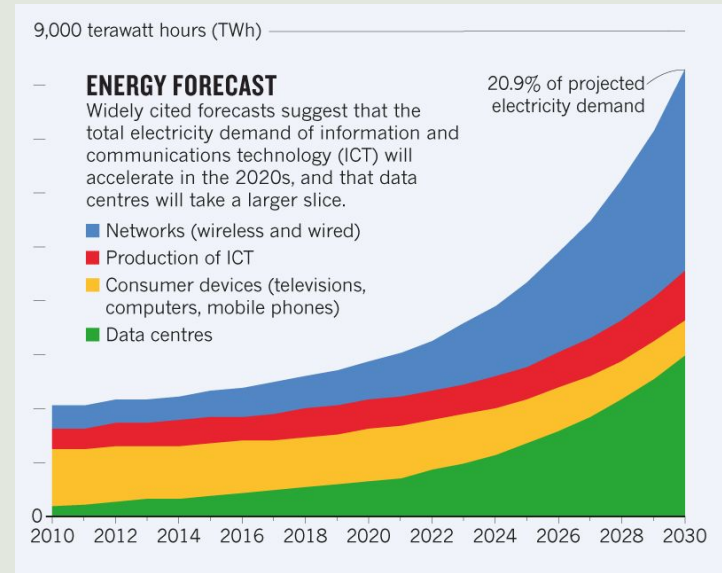# Integration of Sustainability into Undergraduate Engineering Programs

Carissa Trieu

Importance of Sustainability

- Increasing trend of energy and power consumption from data centers and other information related fields contributing to a significant increase in global energy consumption

- Challenges with addressing network energy consumption considering the complexity of network infrastructure with increasing demands

- Cloud computing: service oriented architecture which utilizes some renewable energy to deliver hosted services via the internet

9,000 terawatt hours (TWh)

ENERGY FORECAST
Widely cited forecasts suggest that the total electricity demand of information and communications technology (ICT) will accelerate in the 2020s, and that data centres will take a larger slice.

20.9% of projected electricity demand

- Networks (wireless and wired)
- Production of ICT
- Consumer devices (televisions, computers, mobile phones)
- Data centres

2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030

https://www.akcp.com/blog/the-real-amount-of-energy-a-data-center-use/

Information Technology Relevance

- Information science studies the representation, processing, and communication of information in natural and artificial systems

- Sustainable information technology: application of information technology practices ensuring long–term well–being in all sustainability pillars (economic, social, environmental)

- Further integration of discussion around sustainability in higher education is needed particularly in fields where it is less discussed
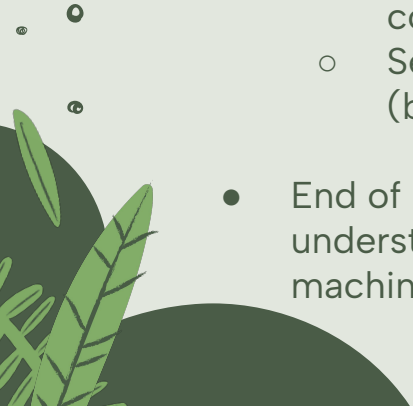
Example Approach

- Exposure to different components covering sustainability issues

- Product lifecycle guidelines and equipment policies for hardware, software, telecommunications

- Curriculum that includes theory, concepts, and applications to the discipline

Figure 1. An approach for sustainability inclusion in Informatics Curricula.
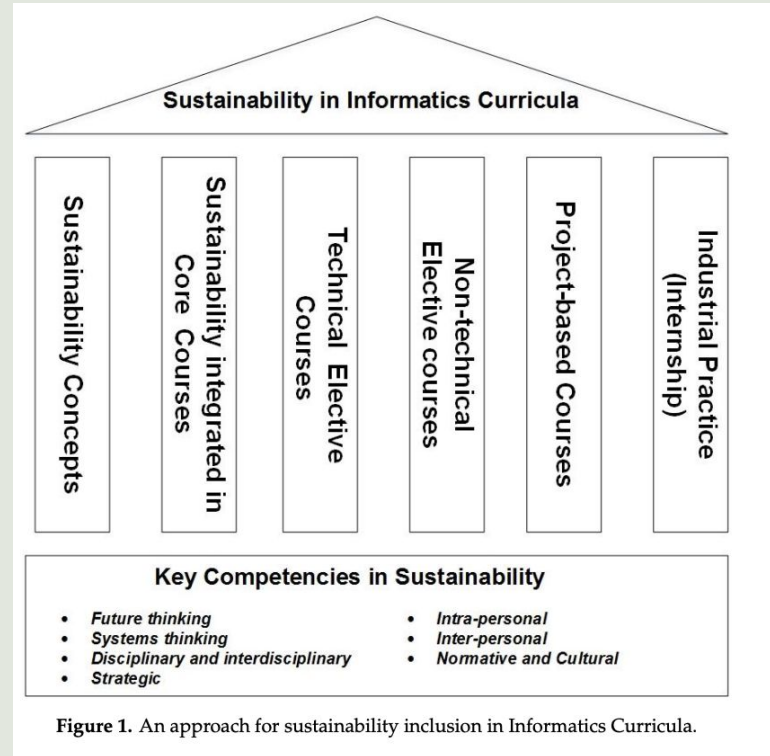
Case Study: Michigan Technical University

- An undergraduate course called Green Computing and Network Services was developed by Dr. Yu Cai at the Michigan Technical University

- Course split into green computing introductory module and server virtualization module
  - Green computing introduction: general principles of sustainability and motivation for green computing, electronic waste disposal, and regulatory compliance
  - Server virtualization: how virtualization works and how it is used to save energy (basis for cloud computing)

- End of course survey displayed that majority of the students had gained understanding of sustainability, achieving optimal performance, setting up virtual machines and other major green computing technologies (Cai 2010)

Case Study: Lappeenranta University of Technology

- Study done on capstone projects which were required to integrate sustainability and software engineering as a part of a research project "Green Citizen @ ICT" (information and communicative technologies) (Palacin-Silva et al 2018)

- All students had prior taken a semester-long introduction which covered how to engineer sustainable physical systems like networks and automation

- Capstone tasked them to create a cyber-physical system that have sustainable concerns included
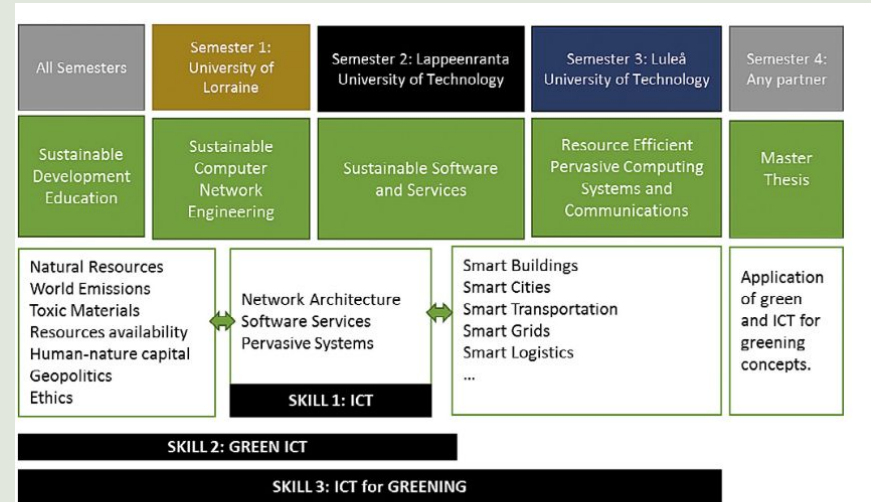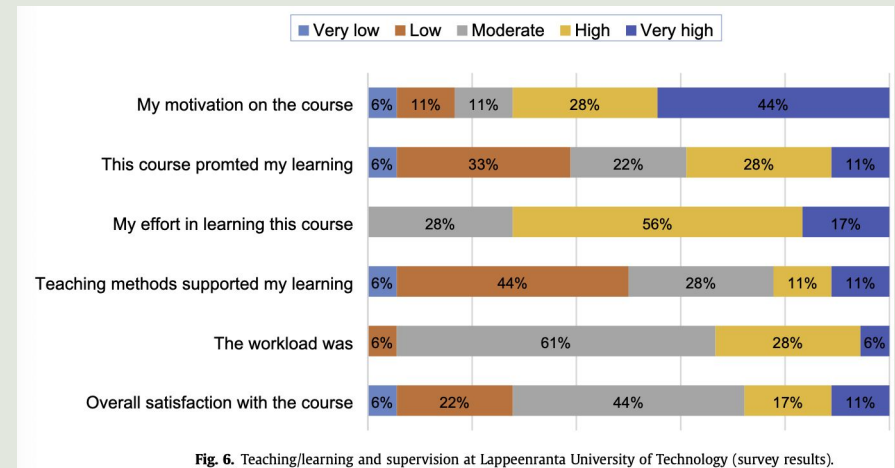

Fig. 1. Structure of the PERCCOM Master Programme and sustainability issues addressed in the Programme [Adapted from (Klimova et al., 2016)].

Continuation on Case Study #2

- Students learned how to design an energy efficient system using software services
  - Acquired technical skills while learning about current sustainability challenges

- This program which had a sustainability focus also attracted more female students compared to the university's other engineering programs
  - Potential increase in workforce diversity

- Several calls to action were highlighted to teach how to tackle practical sustainability challenges in higher education

- Challenges that still remain include the lack of interest from the industry to focus on sustainability development in IT field

Legend: Very low ■ Low ■ Moderate ■ High ■ Very high ■

	Very low	Low	Moderate	High	Very high
My motivation on the course	6%	11%	11%	28%	44%
This course promted my learning	6%	33%	22%	28%	11%
My effort in learning this course			28%	56%	17%
Teaching methods supported my learning	6%	44%	28%	11%	11%
The workload was	6%		61%	28%	6%
Overall satisfaction with the course	6%	22%	44%	17%	11%

Fig. 6. Teaching/learning and supervision at Lappeenranta University of Technology (survey results).

Application at VCU

- Studies show the importance of multidisciplinary knowledge and skills
  - Can also serve as a way to attract more students to exploring new fields

- Implementation of a discussion course related to green information technology, its social responsibility, and sustainable computation to also further develop critical thinking and argumentation skills in relation to the engineering field

- Implementation of sustainability and innovation discussion in SaaS (software as a service) technical course – currently a CMSC elective (CMSC 455)

- Designing a project based module which is heavily application based where students can continue to sharpen technical skills while also addressing sustainability through exploration of real life challenges and problems

Resources

Can B. Aktas, Rosemary Whelan, Howard Stoffer, Edmund Todd, Cindy L. Kern, "Developing a university–wide course on sustainability: a critical evaluation of planning and implementation", *Journal of Cleaner Production*, Volume 106, 2015, Pages 216–221, ISSN 0959–6526, https://doi.org/10.1016/j.jclepro.2014.11.037.

Maria Victoria Palacin–Silva, Ahmed Seffah, Jari Porras, "Infusing sustainability into software engineering education: Lessons learned from capstone projects", *Journal of Cleaner Production*, Volume 172, 2018, Pages 4338–4347, ISSN 0959–6526, https://doi.org/10.1016/j.jclepro.2017.06.078.

Yu Cai. 2010. "Integrating sustainability into undergraduate computing education". In Proceedings of the 41st ACM technical symposium on Computer science education (SIGCSE '10). Association for Computing Machinery, New York, NY, USA, 524–528. https://doi.org/10.1145/1734263.1734439.