CDIO Regional meeting at KTH 9th January 2024

How can CDIO promote - and prevent - transformations towards sustainable futures?

Anders Rosén (aro@kth.se), KTH Royal Institute of Technology

Ola Leifler (ola.leifler@liu.se), Linköping University

Tisdag 9 januari
9.00-10.00 Keynote 3, Anders Rosén & Ola Leifler
Title: How can CDIO promote - and prevent - transformations towards a sustainable society?
Abstract: During the period 2017-2022, the CDIO framework has been critically revised with regards to sustainability and sustainable development. This has resulted in substantial updates that are now implemented in the CDIO Standards 3.0 and the CDIO Syllabus 3.0. This presentation provides an overview of these updates, the motivational and theoretical grounds for the updating, example of how the updated CDIO framework can be operationalized and applied for evaluating and enhancing sustainability in engineering education, and discussions on opportunities and limitations with the CDIO framework.

Tisdag 9 januari
10.30-12.00 Parallella sessioner
Workshop 1, Anders Rosén & Ola Leifler
Title: Doing things better, doing better things, or seeing things differently and acting accordingly?
Abstract: There is a lot of talk about and calls for 'transformation', for example in the UN's 2030 Agenda, in industry, and in education as in the keynote preceding this workshop. But what do we actually mean by 'transformation' in these and related contexts? This workshop provides a space for joint exploration of this question, through discussions and hands on co-creation, and its implications for engineering education and CDIO.

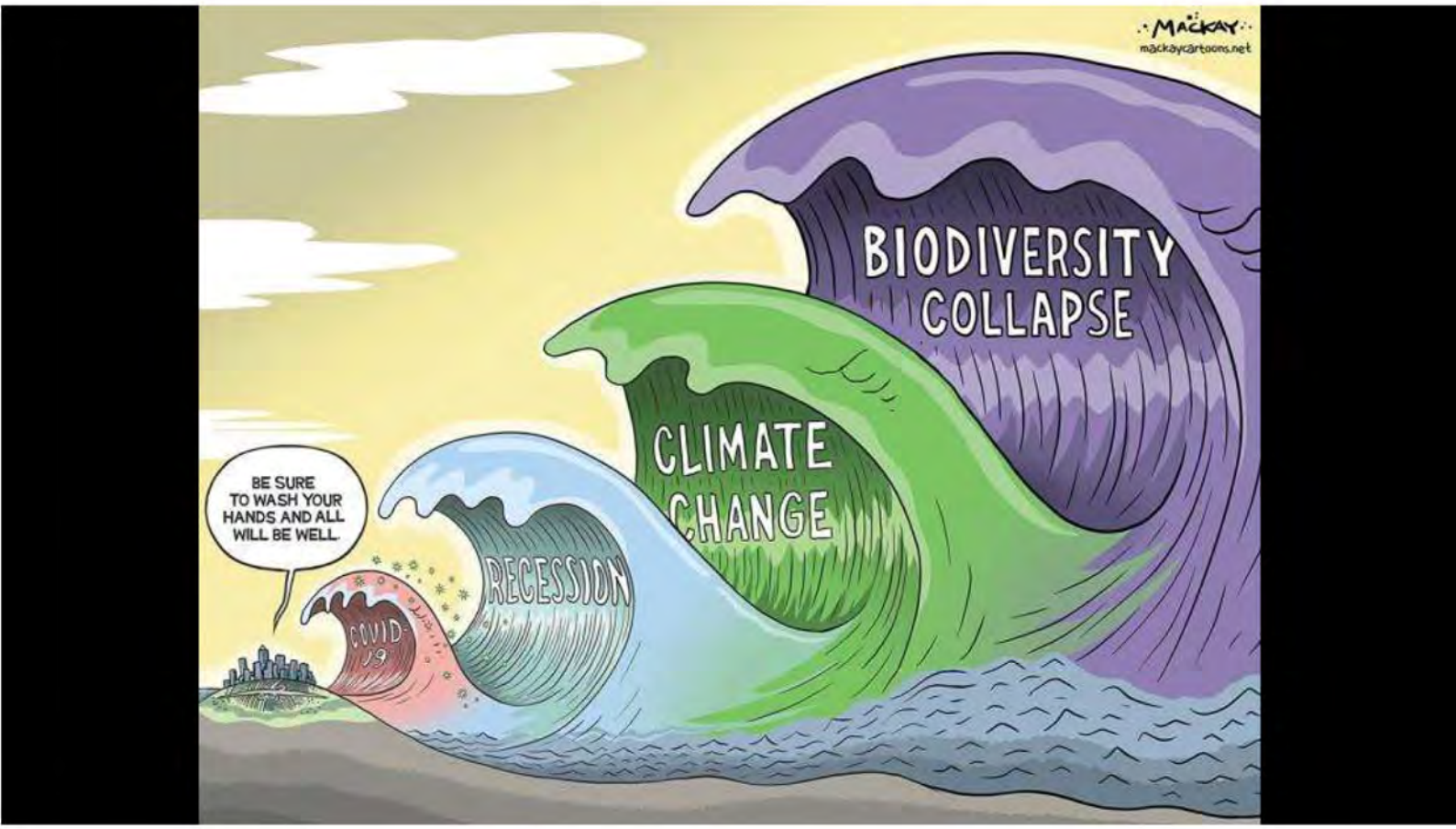
Agenda

Need for transformation

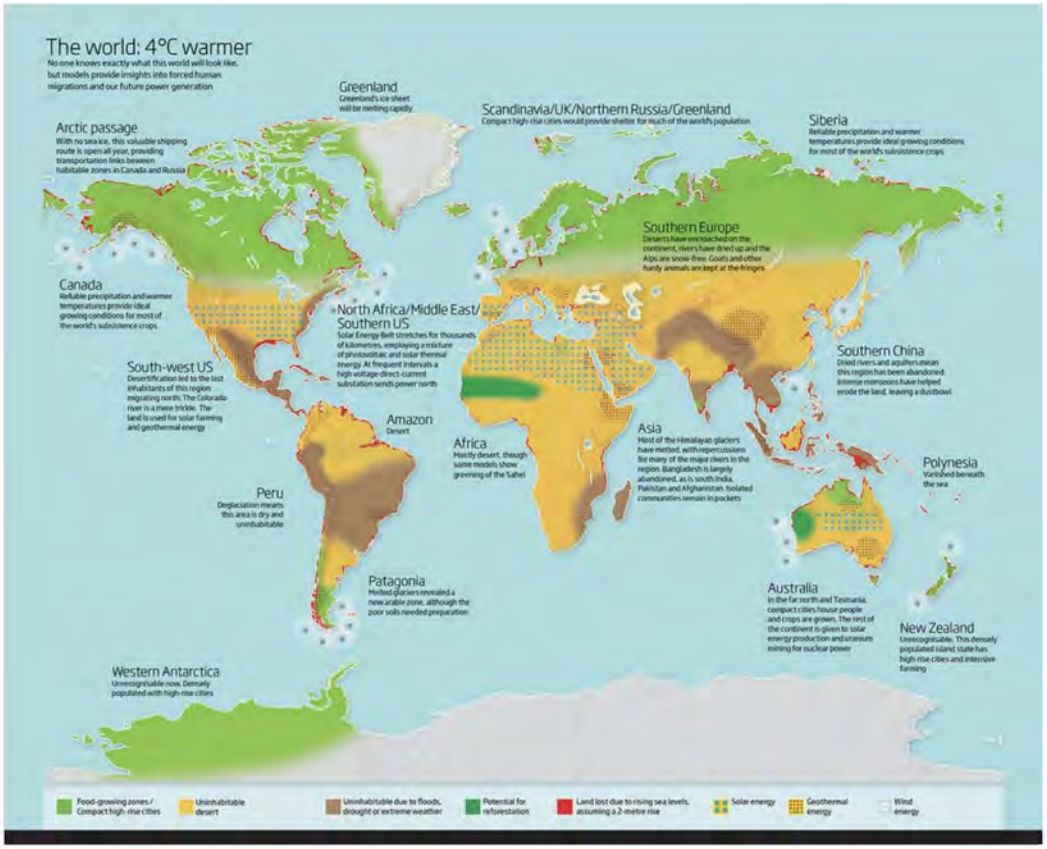
Sustainability updating of the CDIO framework

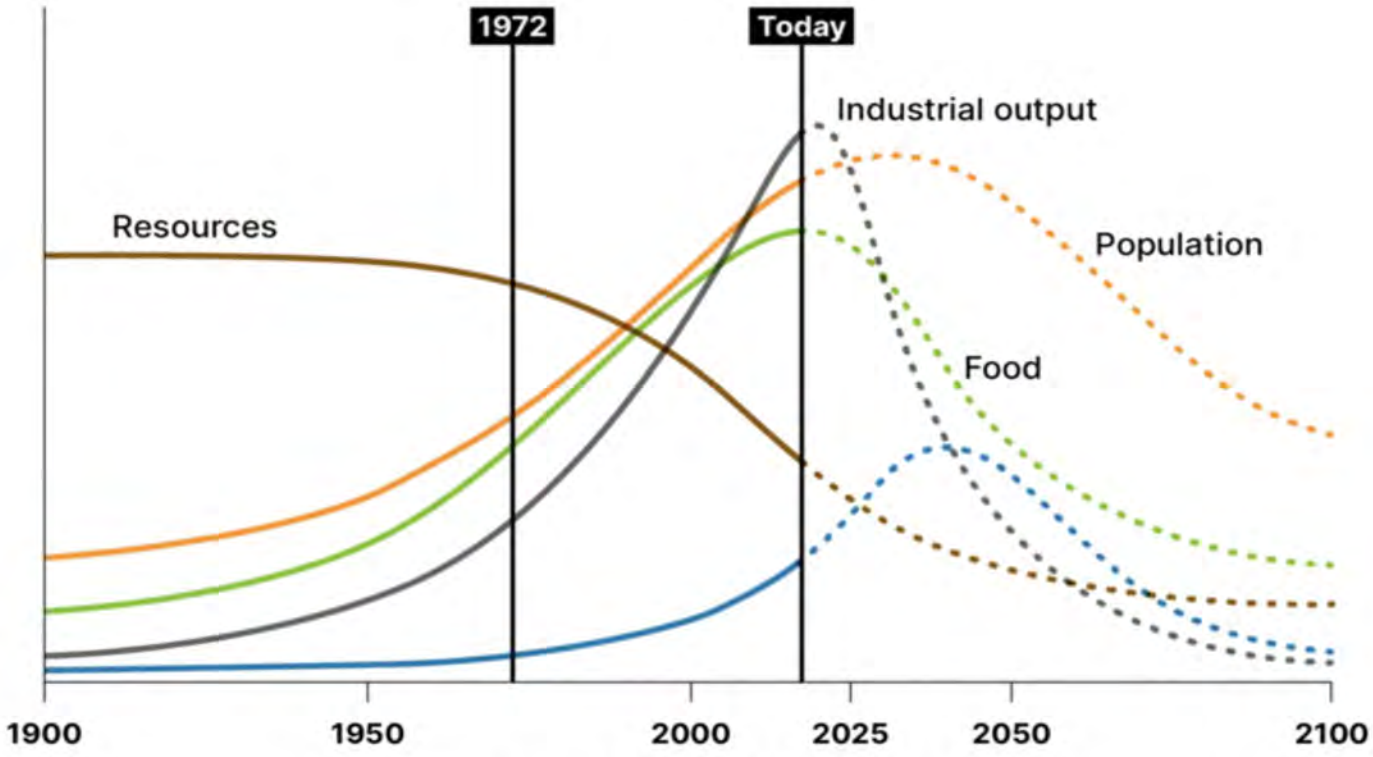
Potential for education and transformation

Shifting worldviews



Anders Rosén, arc@kth.se





Dixson-Declève, S. et al. (2022). Earth for All: A Survival Guide for Humanity. A Report to the Club of Rome. New Society Publishers.

ipcc

INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

…there is a need for transformative systemic change of all aspects of society

Transformation = a change in the fundamental attributes of technological, financial, regulatory, legislative, and administrative systems, as well as in values, norms, belief systems, culture, and conceptions of progress and well-being.

https://www.ipcc.ch/sr15/

Transforming our world: the 2030 Agenda for Sustainable Development

(UN 2015)

United Nations A/RES/70/1

General Assembly

Seventieth session
Agenda items 15 and 116

Resolution adopted by the General Assembly on 25 September 2015

[without reference to a Main Committee (A/70/L.1)]

70/1. Transforming our world: the 2030 Agenda for Sustainable Development

The General Assembly

Adopts the following outcome document of the United Nations summit for the adoption of the post-2015 development agenda.

Transforming our world: the 2030 Agenda for Sustainable Development

Preamble

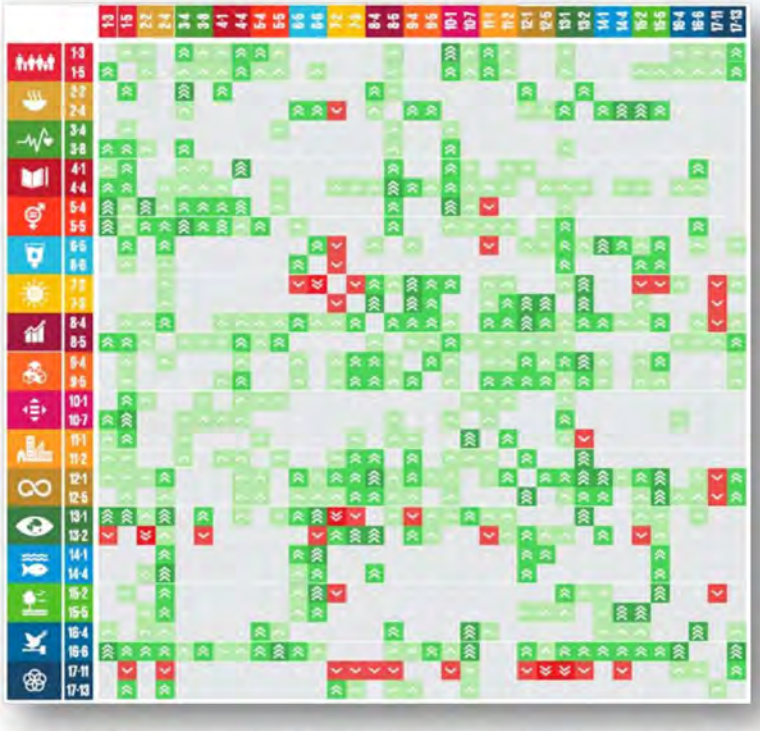
This Agenda is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. We recognize that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development.

All countries and all stakeholders, acting in collaborative partnership, will implement this plan. We are resolved to free the human race from the tyranny of poverty and want and to heal and secure our planet. We are determined to take the bold and transformative steps which we urgently need to shift the world on to a sustainable and resilient path. As we embark on this collective journey, we pledge that no one will be left behind.

The 17 Sustainable Development Goals and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda. They seek to build on the Millennium Development Goals and complete what they did not achieve. They seek to realize the human rights of all and to achieve gender equality and the empowerment of all women and girls. They are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental.

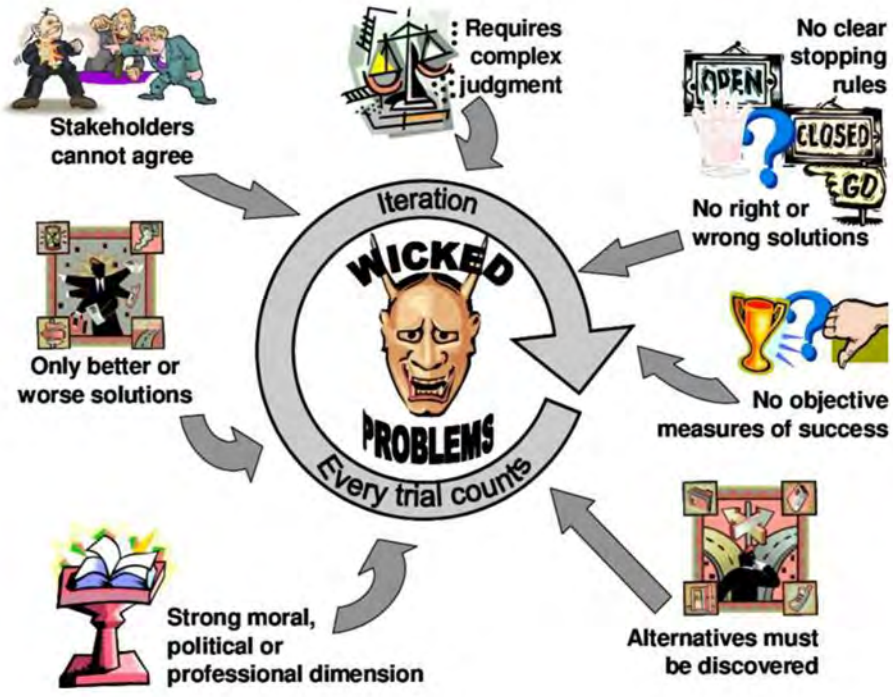
The Goals and targets will stimulate action over the next 15 years in areas of critical importance for humanity and the planet.

Complex problems



Weitz, N., Carlsen, H., Nilsson, M. et al. (2018). Towards systemic and contextual priority setting for implementing the 2030 Agenda. Sustain Sci 13, 531–548. https://doi.org/10.1007/s11625-017-0470-0

Complex problems



Maqsood, T et al (2003) *A soft approach to solving hard problems in construction project management.* In : 2nd int. Conf. on Construction in the 21st Century (CITC-II), Sustainability and innovation in Management and Technology, 10-12 December 2003, Hong Kong

Engineering for sustainable development

…significant gaps between current engineering capability and the needs to meet societal challenges, for example related to human well-being and health, clean water, food security, urban development, energy, biodiversity, and climate change.

…urgent global need to transform engineering education curricula and learning approaches to meet the challenges of the SDGs.

Myths about education (Orr, 1991)

"A second myth is that with enough knowledge and technology we can manage planet Earth.. 'Managing the planet' has a nice a ring to it. It appeals to our fascination with digital readouts, computers, buttons and dials. But the complexity of Earth and its life systems can never be safely managed."

"A third myth is that knowledge is increasing and by implication human goodness. There is an information explosion going on, by which I mean a rapid increase of data, words, and paper. But this explosion should not be taken for an increase in knowledge and wisdom, which cannot so easily by measured. What can be said truthfully is that some knowledge is increasing while other kinds of knowledge are being lost."

What Is Education For? Six myths about the foundations of modern education, and six new principles to replace them By David Orr, 1991

Updating the CDIO framework with regards to sustainability

CDIO

An idea of what engineering students should learn

- CDIO Syllabus (*engineers who can engineer*)

A methodology for engineering education reform

- CDIO Standards (*guiding education program development*)

A community for learning and sharing experiences

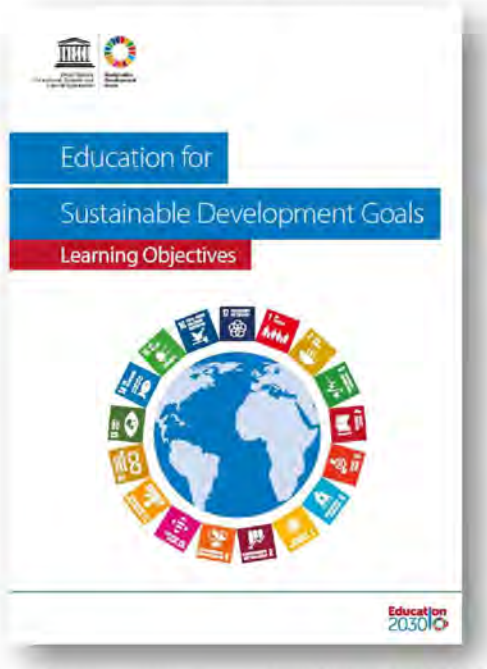
- Yearly conference, working meetings

Education for Sustainable Development

as framed by UNESCO

Crucial features:
(UNESCO 2017)

- Integrating sustainability content
- Developing key sustainability competencies



Pedagogical approaches:
(UNESCO 2017)

- Learner-centered
- Action-oriented
- Transformative

http://unesdoc.unesco.org/images/0024/002474/247444e.pdf

CDIO updated with elements from ESD

Crucial features:
(UNESCO 2017)

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- Developing key sustainability competencies

CDIO Standards

CDIO Syllabus

Pedagogical approaches:
(UNESCO 2017)

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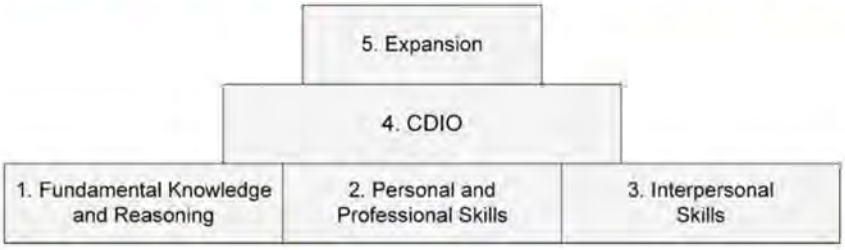
CDIO Syllabus – sustainability updating 2019-2022



Various updates, for example additions of:

2.4.5 Critical Thinking
Question norms, practices and opinions

2.5.1 Ethics, Integrity and Social Responsibility
Prepared for debates about values, ethics, morality

3.1.2 Multi-Perspective Collaboration
Facilitation of diversity and inclusiveness in group processes across cultures, social groups and communities

4.3.1 Understanding Societal and Planetary Goals and Constraints
Power, politics, authority in strategy building and change

CDIO Standards – sustainability updating 2017-2020

12 "core" standards:

- Engineering education philosophy and aims (Standard 1);
- Curriculum development (Standards 2, 3, 4);
- Engineering projects and workspaces (Standards 5, 6);
- Teaching and learning methods (Standards 7, 8);
- Faculty development (Standards 9, 10);
- Assessment and evaluation (Standards 11, 12).

For example:
"Adoption of the principle that sustainable product, process, system, and service lifecycle development and deployment – Conceiving, Designing, Implementing and Operating – are the context for engineering education"

CDIO Standards – sustainability updating 2017-2020

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New 'optional' Standard for Sustainable Development

Optional Standard for Sustainable Development

Description:

The program emphasizes environmental, social, and economic, sustainability in the adoption of the CDIO principles as the context for engineering education. Sustainability related knowledge, skills, and attitudes are explicitly addressed in program goals and learning outcomes. Aspects of sustainable development are integrated in several mutually supporting disciplinary courses and projects, possibly in combination with specific sustainability courses. Concepts of sustainability, potentials and limitations of science and technology, and related roles and responsibilities of engineers, are established at an early stage of the education. Design-implement experiences provide students with opportunities to apply and contextualize sustainability knowledge, skills, and attitudes, both in the development of new technology and in the reuse, redesign, recycling, and rethinking, of existing technology... active, experiential, and transformative learning activities develop students' key competences for sustainability. Enhancement of faculty competences for sustainability and related teaching competences is actively promoted. Approaches appropriate for assessing sustainability related learning outcomes are implemented. The integration of sustainable development is evaluated by students, faculty, industry, and societal stakeholders, and in relation to relevant UN and other frameworks.

Rosén A, Hermansson H, Finnveden G, Edström K, (2021). "Experiences from Applying the CDIO Standard for Sustainable Development in Institution-Wide Program Evaluations", 17th International CDIO Conference, Chulalongkorn University & Rajamangala University of Technology, Thanyaburi, Bangkok, Thailand, June 21-23, 2021.

Optional Standard for Sustainable Development

Rubric	Criteria
0	There are no sustainable development learning experiences in the program.
1	Minor sustainable development learning experiences…
2	At least two sustainable development learning experiences…
3	…
4	…
5	The CDIO standard for sustainable development is fully implemented.

(as modified in Rosén et al 2021)

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Optional Standard for Sustainable Development

Rubrics:	0	1	2	3	4	5
Minor SD learning experiences	0	1	1	2	>	≥
SD Knowledge		✔	✔	✔	✔	✔
Substantial SD learning experience			1	2	>	≥
Early intro to SD				✔	✔	✔
Environmental, Social, Economic				✔	✔	✔
SD Skills				✔	✔	✔
SD Attitudes & Key competencies					✔	✔

(as modified in Rosén et al 2021)

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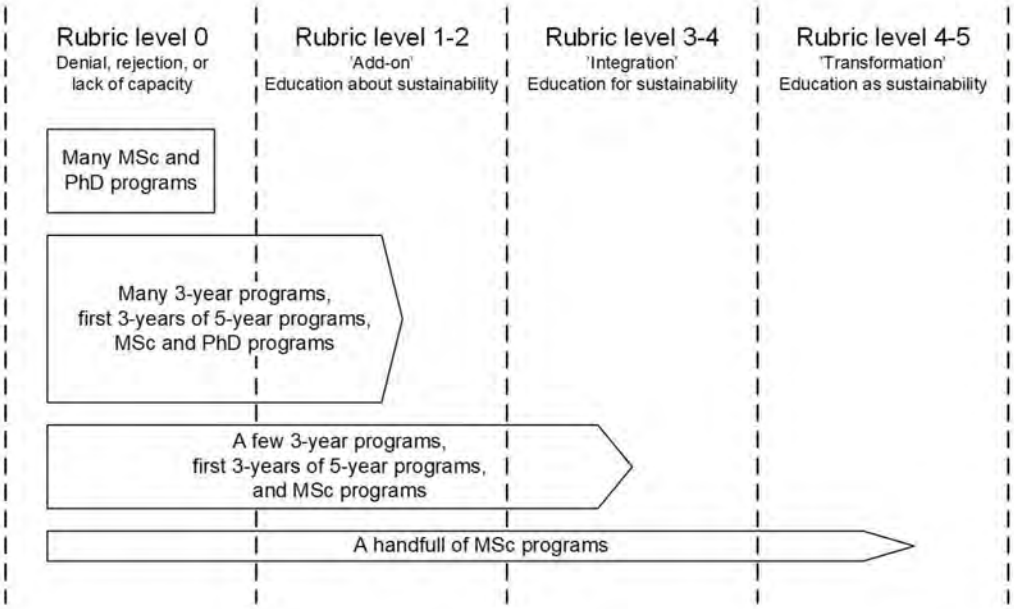
Application in institution-wide program evaluations at KTH



Identified **needs for improvements**, e.g.:

- **introduction** early in the program;
- **progression** through the program;
- sustainability **skills**, **attitudes**, and **competencies** (in addition to knowledge);
- **social** sustainability (incl equality & justice);

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Application in institution-wide program evaluations at KTH

Examples of reactions :

Electrical Engineering (R1)

"Good to have a number telling how bad we are"

Clear call for action to enhance the status of sustainability in the program.

Civil Engineering (R3)

"We should be better than this"

Positive confirmation that 10 years work has resulted in visible change.

Injection to continuing efforts.

Rosén, A., Liedholm-Johnson, E., Jaldén, J., (2023). Evaluating and Enhancing the Status of Sustainability in Engineering Education. Proceedings of the 19th International CDIO Conference, hosted by NTNU, Trondheim, Norway, June 26-29.

Electrical Engineering (R1)

Weaknesses:
- Very few sustainability related learning experiences.

Strengths:
- Project-based learning! One project-based course in year 1, one in year 2, which together with the BSc thesis project in year 3 enable progression of project-based learning. Integrating some ethics, however, not yet sustainability.

Opportunities:
- Move from and 'add-on' towards an 'integration' approach to sustainability…
- …by integrating a progression of sustainability in the three project-based courses through yrs 1-3.
- Take inspiration from the Civil Engineering program.

Barriers:
- Techno-centred, years 1-3 heavy on electrical engineering content, preparing students for nine different MSc programs.
- Electrical engineering is the strongest research area at KTH, strong-minded faculty cautious about their respective subjects and courses.

Civil Engineering (R3)

Strengths:
- Rich with sustainability learning experiences also developing students' skills.
- Sustainability engaged faculty and research groups.
- Interdisciplinary since Civil Engineering is naturally including social science, humanities, and other non-technical dimensions.

Weaknesses:
- Limited in project- and problem-based learning.

Opportunities:
- Move from an 'integration' towards a 'transformation'/'rebuild' approach to sustainability…
- …for example by rebuilding 'Introduction to the Planning and Building Process', including a challenge-driven project, maybe also add yet another challenge-driven/project-based course in year 2 or 3.
- Take inspiration from the EE program on project-based learning.

Barriers:
- Rebuilding requires resources and competence development and will probably meet resistance from some faculty members.

KTH's new sustainability objectives for education 2021-2025

1. KTH is a leading technical university within education for sustainable development in which all students, post-graduation, will be able to drive and participate in the transition to sustainable development and an equal and climate-neutral society.

Learn more about objectives, sub-targets and measures for education

Sub-targets to be achieved by the end of 2025 at the latest

1.1 Within KTH, sustainable development has been integrated into all educational programmes at all levels so that students, post-graduation, are aware of technology's role in society and people's responsibility for how it is used. They possess the knowledge and skills to drive sustainable societal development and contribute to the transition to an equal and climate-neutral society.

1.2 Within KTH, all teaching, Bachelor and Master's programmes, as well as the architecture programme, have reached at least level 3i in the CDIO standards for sustainable development. All Master's and doctoral programs have reached at least level 2 in the CDIO standards for sustainable development.

Transformation potential of the CDIO framework

Problem complexity

Chaotic problem	Disasters beyond complexity
Complex problem	Unknown problem (rather: predicament) Unknown solution (rather: response)
Complicated problem	Known problem Unknown solution
Obvious problem	Known problem Known solution
No problem	

Problem framing
('Cynefin' framework, UNESCO 2021 and Snowden & Boone 2007;
'Wicked problems', Rittel & Webber 1973).

Engineering problems & solutions

…there is an urgent global need to transform engineering education curricula and learning approaches

Domains of problems and responses

Clear/simple/tame problems

- What are the facts?
- How can we categorize them?
- Which rules or best practices exist?

Complicated problems

- What are the requirements from all the different stakeholders?
- What is an engineering analysis of the situation?
- Which blueprint can we provide for a solution?

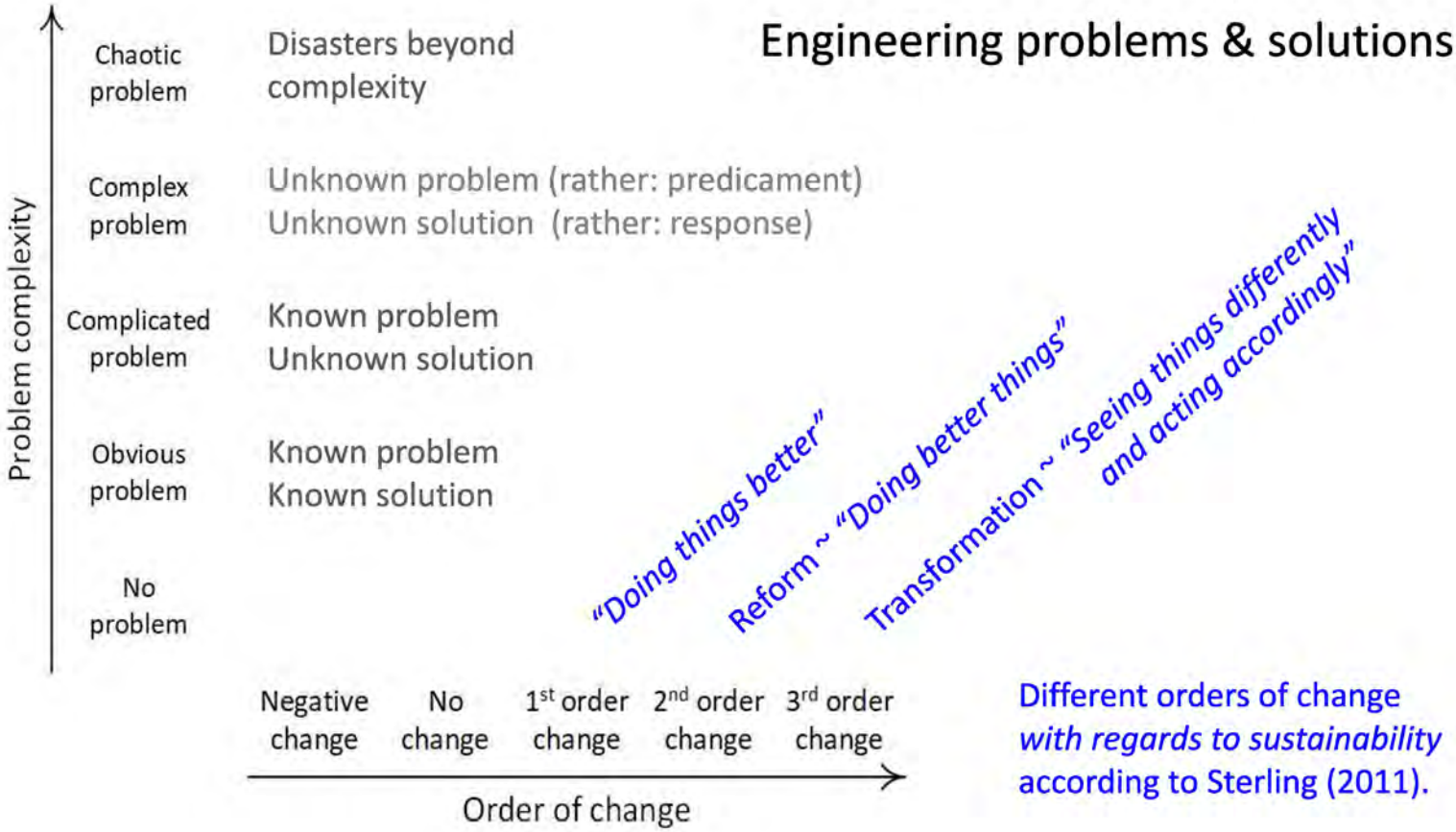
Chaotic problems

- What can we do right now to get out of danger?
- Where is there stability in the chaos?
- How can we move to one of the other types?

Complex problems

- Which safe-to-fail experiments can give us information about the system?
- What patterns and weak signals can we sense?
- Which are the wisest collective steps?

Engineering problems & solutions



Different orders of change *with regards to sustainability* according to Sterling (2011).

Negative change

How can we sell more cars?
How can we construct a "cool" car?

No change

How can we create a car that is safer/faster/better **in the same way** as we produced the previous model?
E.g., how can we create a fossil-fueled car that simply uses less fuel, is safer for passengers, … in the same way as we have optimized the past 100 years?

Doing things better

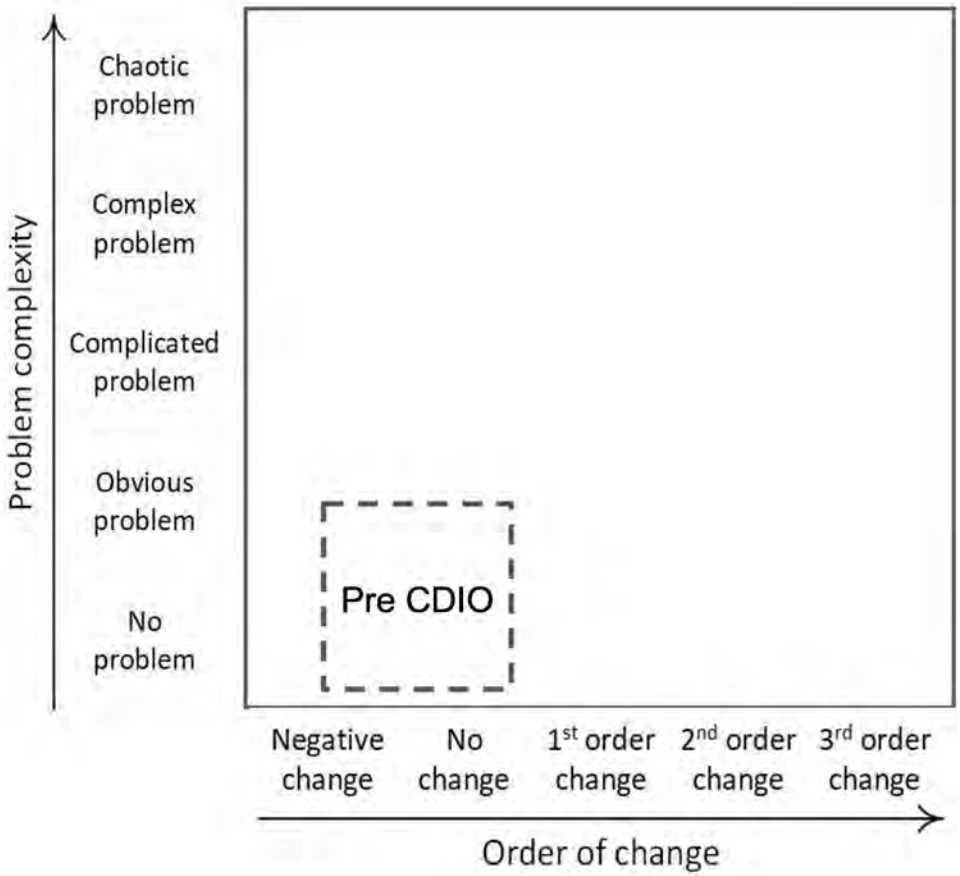
Given a thing, what types of harm comes from it?
How can we do the thing better knowing about the harms?
How can we make a car more "efficient" so that it does not emit carbon(e.g. shift to EV:s) or require blood minerals (e.g. cobalt) in batteries (EV:s)?
How can we create a car that does not cause fatal wildlife accidents?

Doing better things

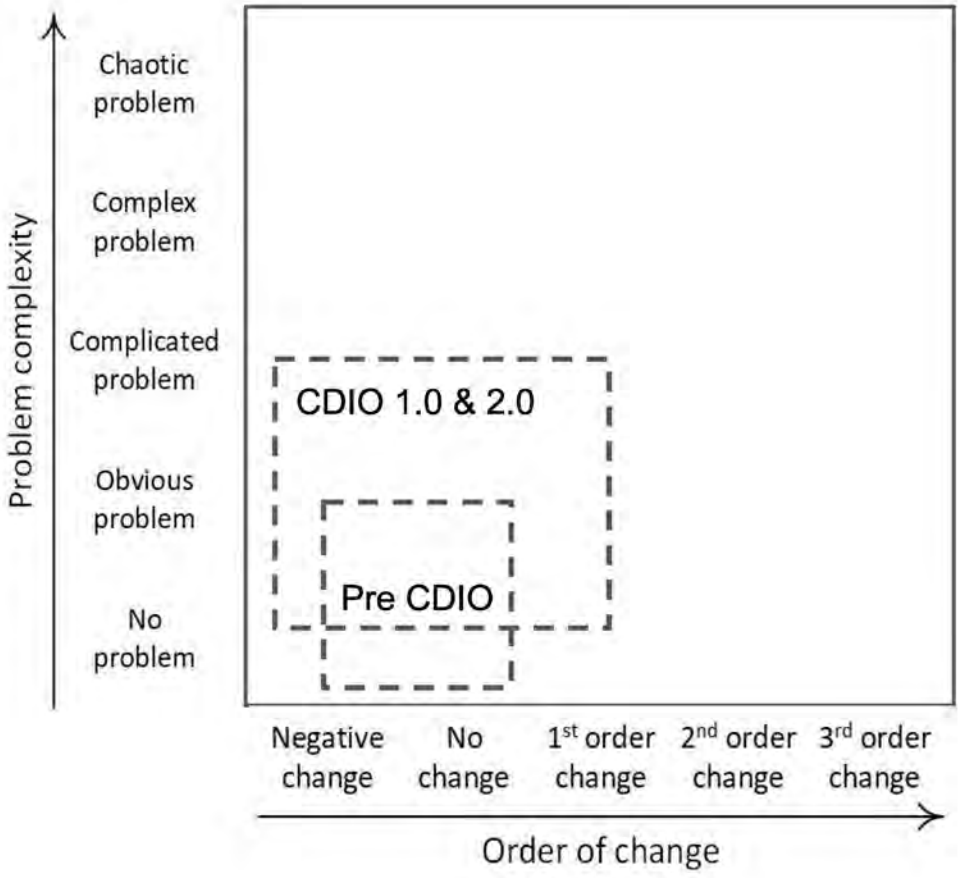
What is the real problem to be solved?
Which options are there for solving that problem?
What entirely new types of things should we build?

Seeing things differently

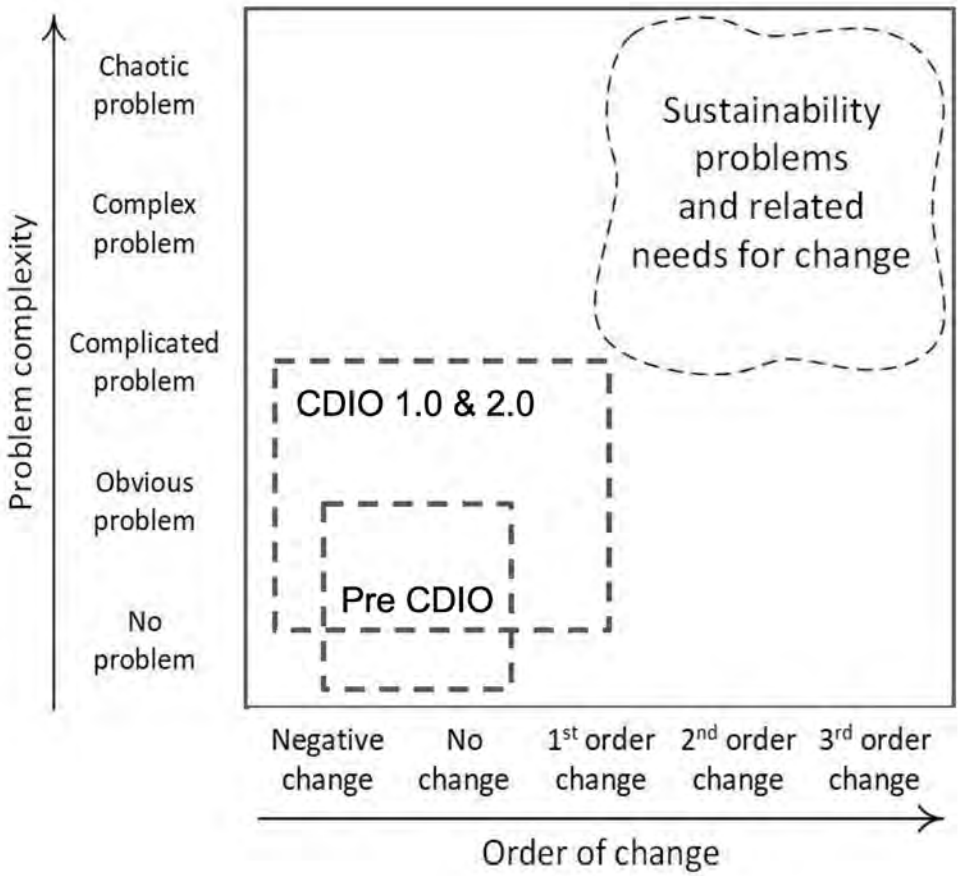
Who gets to say what a legitimate problem is?
Who gets to say which solutions are admissible?
Are limits to possibility set by our technologies and institutions, demands of the living world or our worldviews?



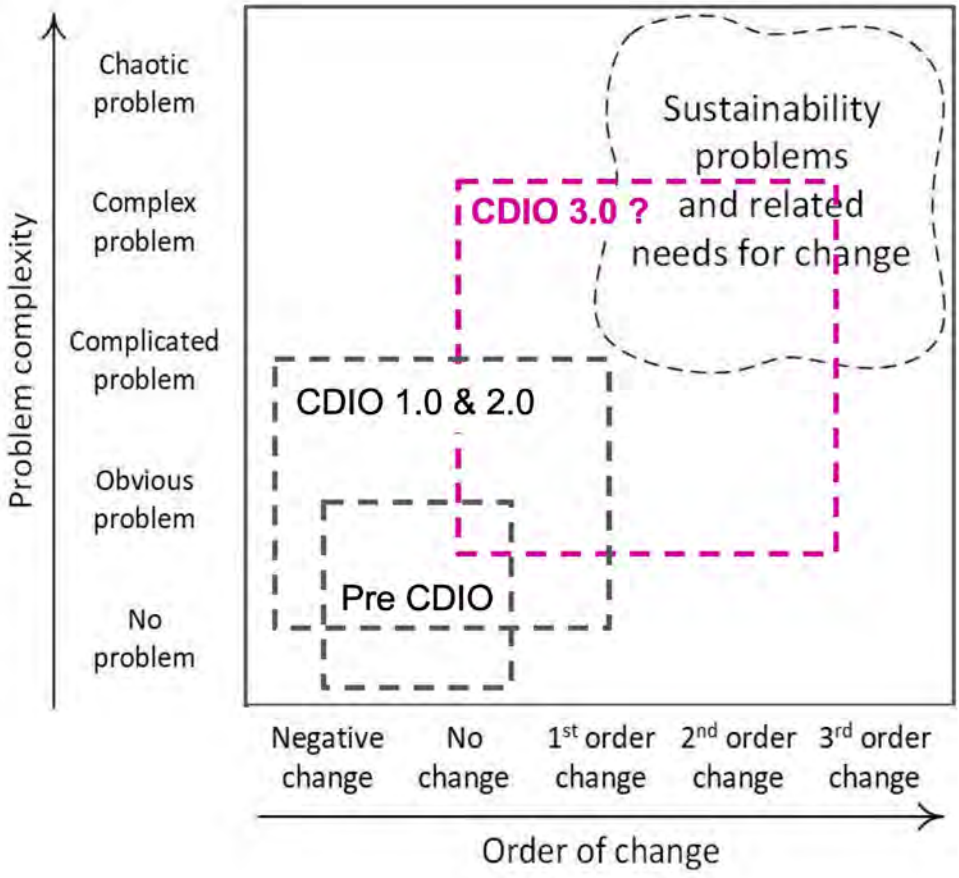
Engineering education



Engineering education
reform



Where and what should engineering education be in this landscape of problems and needs for change?



Engineering education **transformation**

Optional Standard for Sustainable Development

Rubrics vs Sterling (2011) & Kolmos (2016) :

Education strategies		**State of education**	**Rubric**
Add-on	(weak)	Education *about* sustainability	1-2
Integration	(strong)	Education *for* sustainability	3-4
Transformation	(very strong)	Education *as* sustainability	5 ?

(as modified in Rosén et al 2021)

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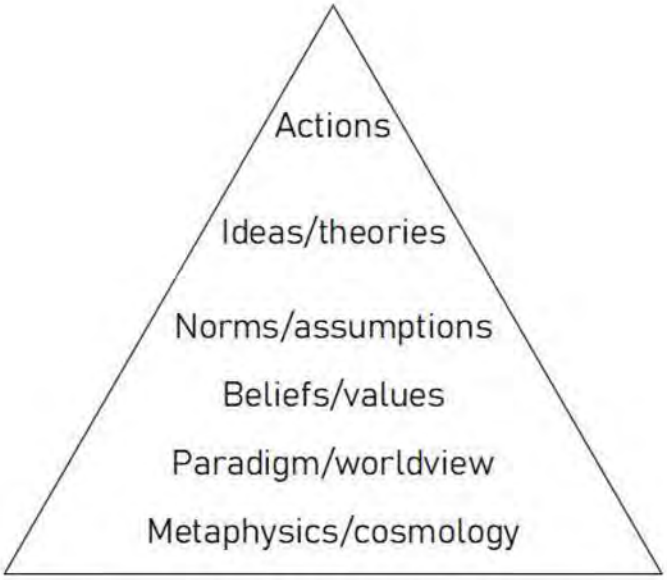
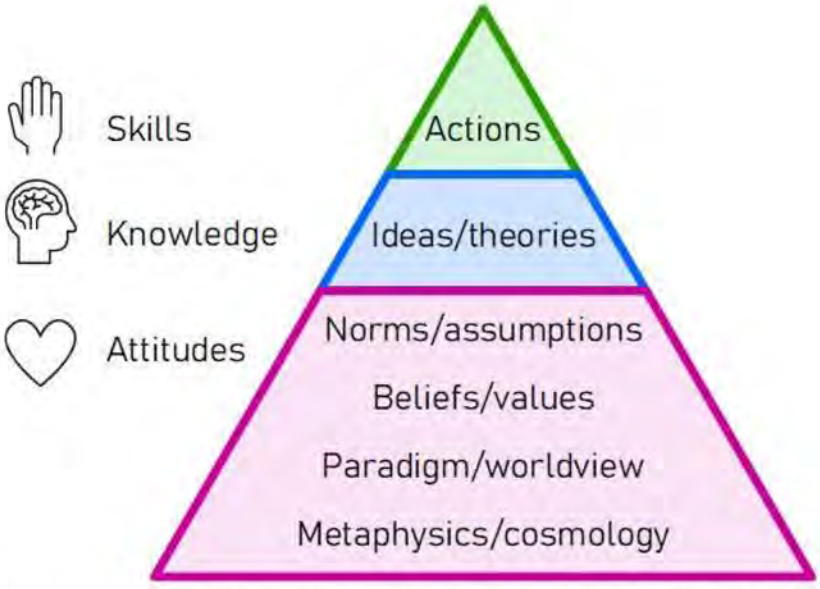
Levels of 'knowing' (Sterling 2011)



Sterling, S. (2011). "Transformative Learning and Sustainability: Sketching the Conceptual Ground." Learning and Teaching in Higher Education 5 (11): 17–33.

Levels of 'knowing' (Sterling 2011)



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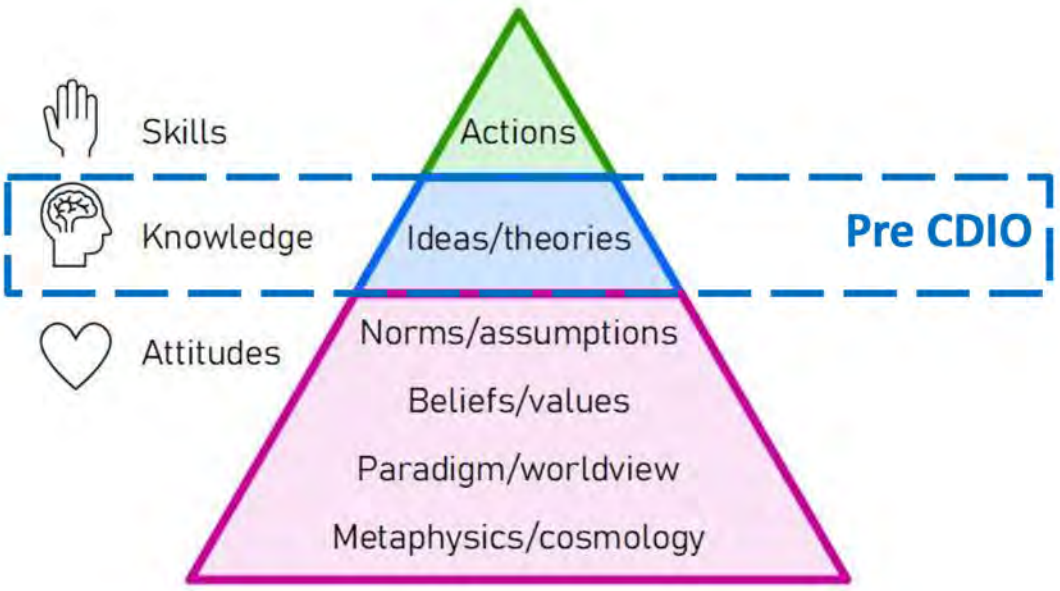
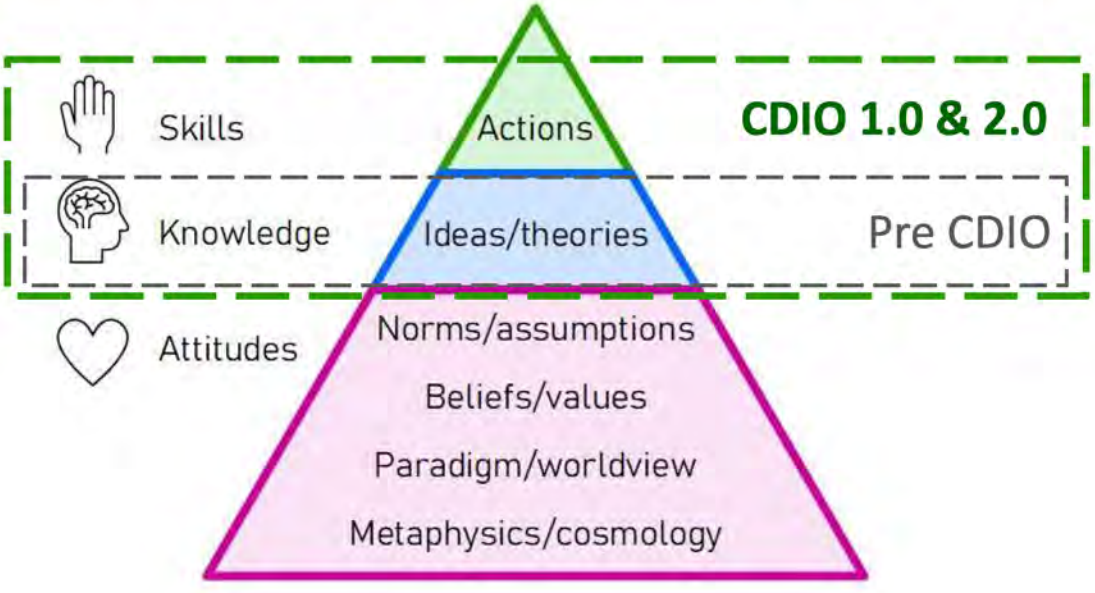
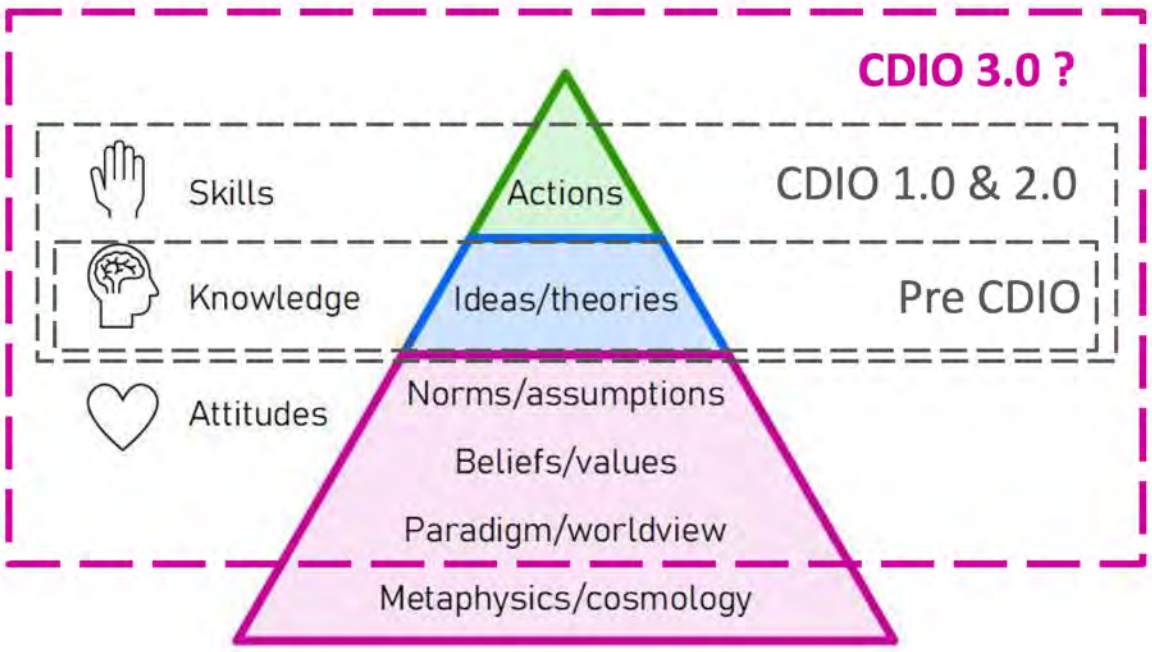
Engineering education



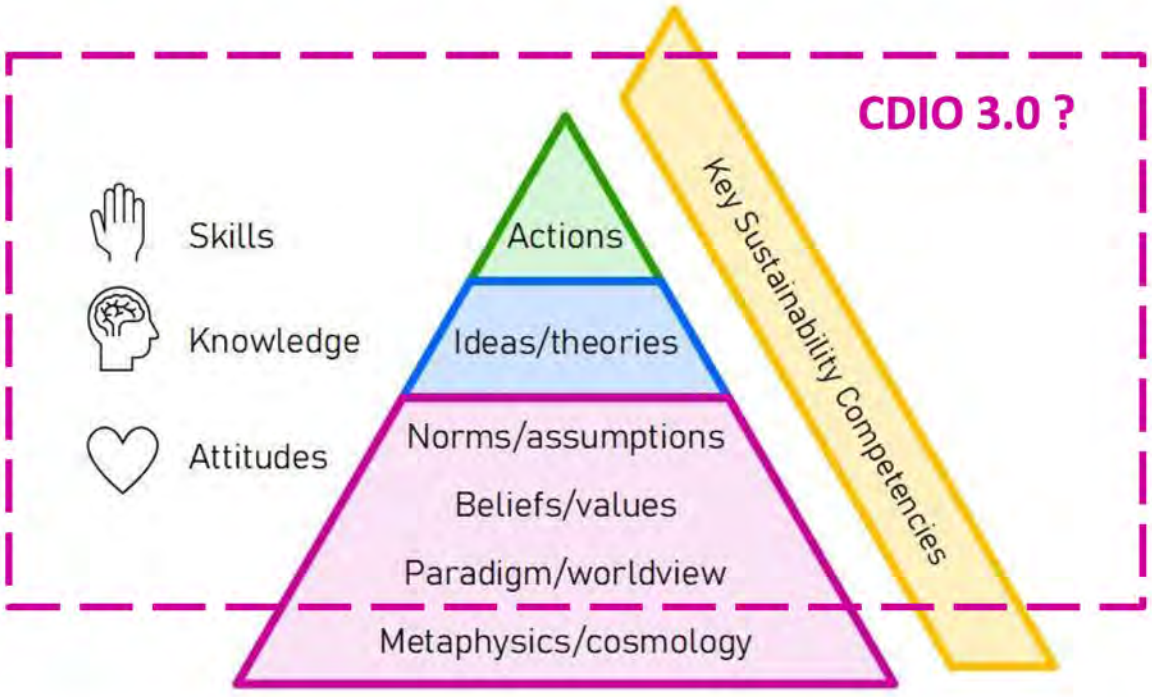
Engineering education **reform**



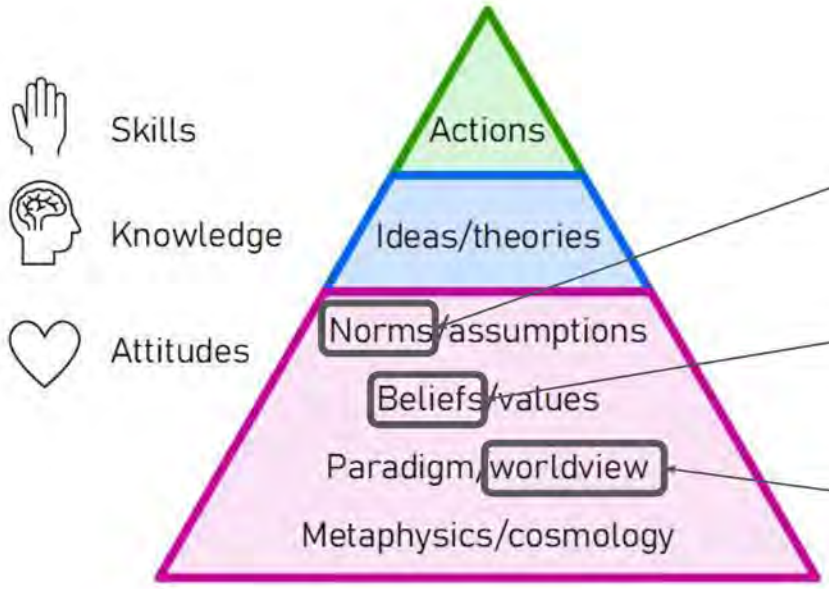
Engineering education **transformation ?**



Engineering education **transformation ?**



Worldview Pre-CDIO

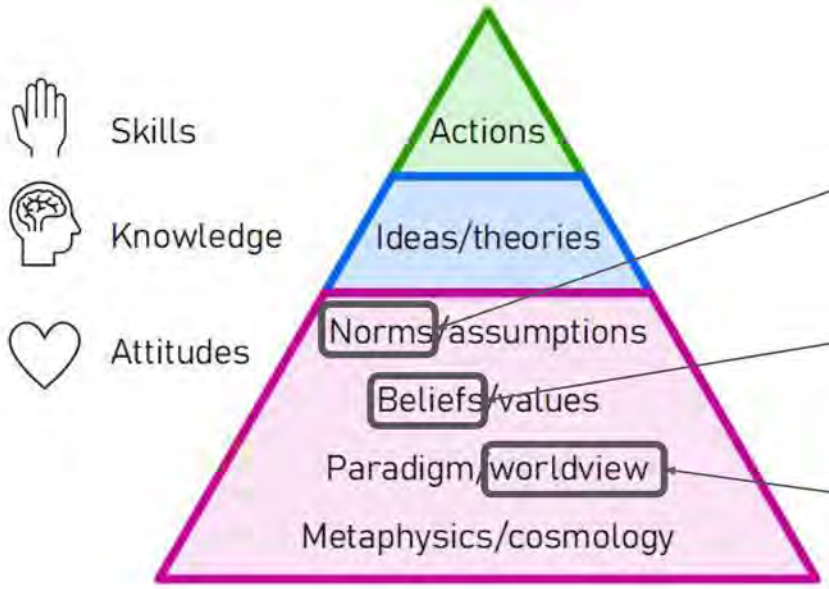


Specialization and practical courses should be deferred towards the end of an education once mastery of basic subjects has been attained.

Specialized technical courses require advanced-level theoretical knowledge from basic courses.

Education needs to be grounded in academic research within disciplines. Higher education needs solid grounding in all relevant scientific theory.

Worldview CDIO 2.0

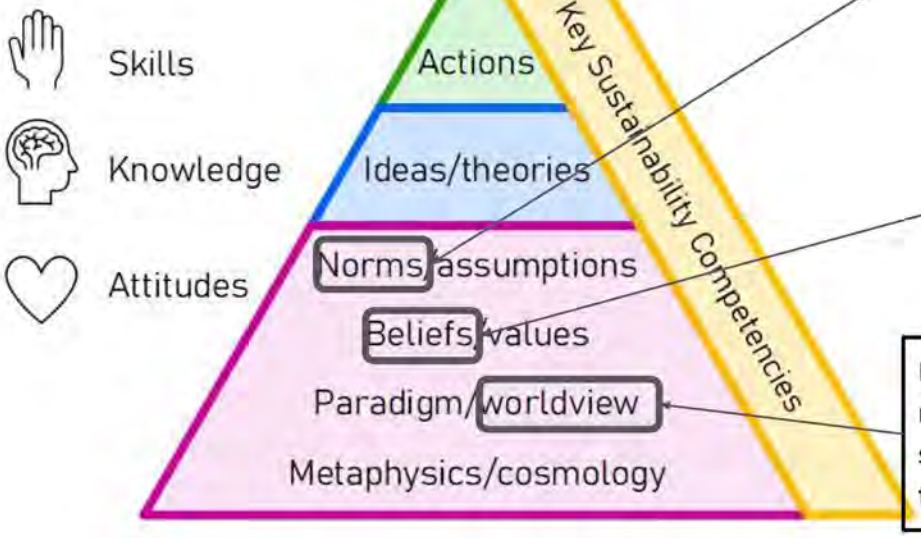


Applications should direct the need for theoretical knowledge. We should have student-centered active learning centered on industry projects

Learning happens when you integrate knowledge. Doing practical exercises is a powerful way to learn.

Engineering education needs to produce industry-ready graduates. Learning activities should reflect relevant engineering activities in industry.

Worldview CDIO 3.0?



Transformative learning demands transformative experiences that are embedded in the real world where we can sense, act and reflect as full human beings together with our students.

Learning reinforces behaviour, beliefs and worldviews. Working with complex and chaotic situations requires empathy, care, humility, openness, and stamina in face of the unknown.

Engineering education needs to be relevant in relation to needs for a just and ecologically sound society. Learning should promote transformations towards such a society.

Other paradigms

We are embedded as members of in a living, feeling, thinking web of life

The older the knowledge, the more valuable it is. Nature encodes billions of years of knowledge about being alive.

First, we must know how to be good community members among all life, and good ancestors, then we may learn how to master skills towards those ends

Kimmerer, R. (2013). Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants. Milkweed editions.

Frames/worldviews

"We have come to enshrine *anthropocentrism*, *individualism*, *exploitation of humans and nature*, and *unfettered economic and technological growth* into decontextualized, taken-for-granted root or guiding metaphors. These metaphors forged the status quo into being and continue to guide and perpetuate it. Taken together, they form the four cornerstones of what I refer to as *the Dominant Metanarrative*, which came into being both slowly and spontaneously, through accretion, in an unplanned manner."

Glasser, H., 2018. Toward robust foundations for sustainable well-being societies: Learning to change by changing how we learn. Sustainability, human well-being, and the future of education, pp. 31-89.

Summary

Need for transformation

Sustainability updating of the CDIO framework

Potential for education and transformation

Shifting worldviews

Welcome to join our workshop in room M37!

Questions?