Anders Rosén's SPOTLIGHT seminar
at the KTH Department of Learning
12th November 2021

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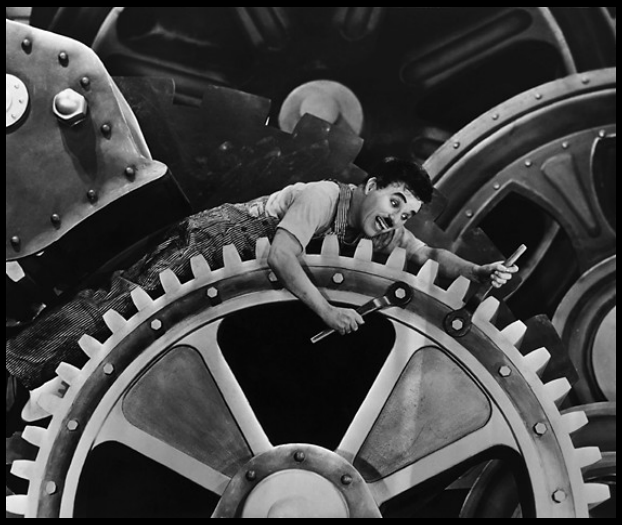

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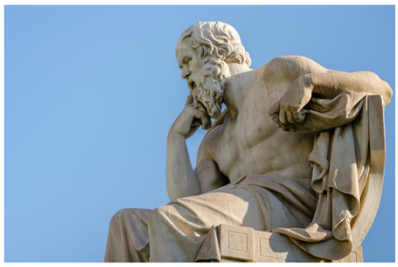

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1628 Vasa

1912 Titanic

2006 Finnbirch

1687 Newton's *Principia*

1775 af Chapman's *Tractat om Skeppsbyggeriet*

1939 Rahola's *The Judging of Stability of Ships*

2010 KTH Ship Dynamics Research Group

8

IMO INTERNATIONAL MARITIME ORGANIZATION

TRANSPORT STYRELSEN

UN authority
HQ in London

9

Sustainability education...

10

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Sustainable high-speed craft?

12

Example of integration of sustainability in a KTH course

SD2705 High-Speed Craft 6.0 credits

Intended learning outcomes

After passing the course, the students should be able to:

1. ...

2. Demonstrate an ability, from a holistic perspective, to critically, independently and creatively

    a) ....

    b) ...

    c) create, analyse and evaluate different solutions for the hull structure and other parts of high-speed craft.

3. ...

4. ...

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Example of integration of sustainability in a KTH course

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Intended learning outcomes

After passing the course, the students should be able to:

1. ...

2. Demonstrate an ability, from a holistic perspective, to critically, independently and creatively

    a) ....

    b) ...

    c) create, analyse and evaluate different solutions for the hull structure and other parts of high-speed craft.

3. ...

4. ...

5. Demonstrate an ability to evaluate high-speed craft concerning technical efficiency, and related social and economic aspects, as well as

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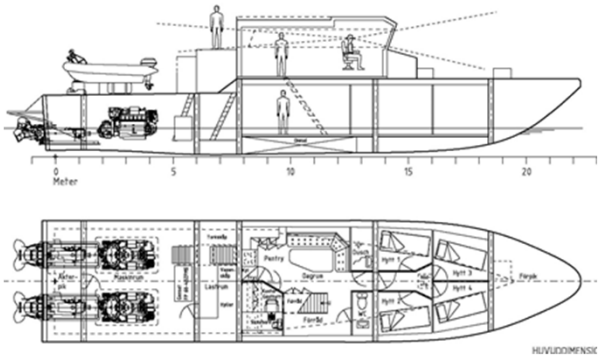
Example of integration of sustainability in a KTH course

SD2705 High-Speed Craft 6.0 credits

Project-based, students working 2&2 designing the propulsion system and the hull structure for a search-and-rescue vessel based on input from a real designer/shipyard, e.g.:



Length	24	m
Width	5	m
Tentative mass	48	ton

Operational profile, 500 h/yr

30 kn	25 %
20 kn	50 %
10 kn	20 %
5 kn	5 %

DNV class notation +1A1 R1 HSLC Patrol E0
IMO HSC Code

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Example of integration of sustainability in a KTH course

SD2705 High-Speed Craft 6.0 credits

Students are facing various dilemmas of conflicting requirements and have to decide on appropriate trade-offs, e.g.:

1. **Social** motivation **for** travelling at high speed
2. **Social** motivation **against** travelling at high speed
3. **Economic** motivation **against** travelling at high speed
4. **Environmental** motivation **against** travelling at high speed

Tools:

- Design methodologies aligned with UNs International Maritime Organization (IMO) policies
- Environmental pricing (e.g. CO2 emission rights ~30 Euro but 60 Euro or more is claimed needed for reaching the Paris agreement)
- Social pricing (e.g. Value of Statistical Life, ~2.5 MEuro in Sweden)

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What does it mean that sustainable development is integrated in a course?

In what different ways and to what extent can it be done?

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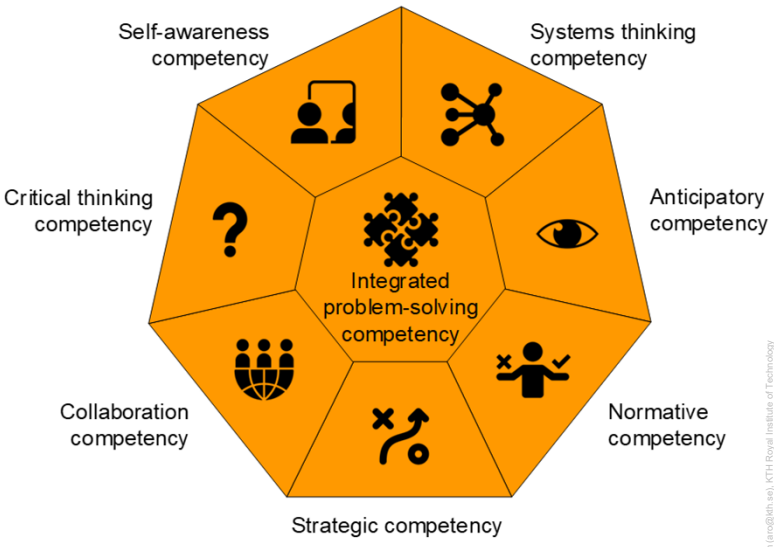
What does it mean that sustainable development is integrated in a course?
In what different ways and to what extent can it be done?

Key **competencies** for sustainability — C

Knowledge for sustainable development — K

Skills for sustainable development — S

Exposure to sustainability issues — E



https://kth.diva-portal.org/smash/get/diva2:1349004/FULLTEXT01.pdf

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Education for Sustainable Development according to UNESCO (2017)

Crucial features :

- Should integrate sustainable development concepts and content
- Should develop key competencies for sustainability
- Should truly matter and be relevant to the students

Pedagogical approaches :

- Learner-centred
- Action-oriented
- Multi-perspective
- Transformative Transgressive

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

https://kth.diva-portal.org/smash/get/diva2:1349004/FULLTEXT01.pdf

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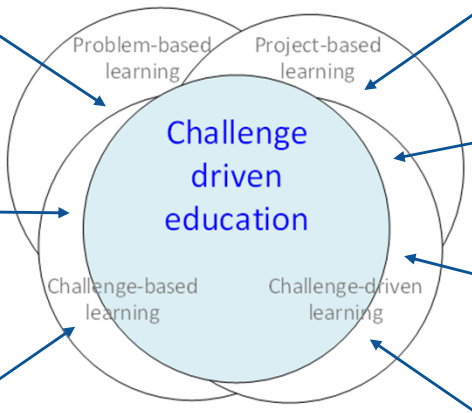
Challenge-driven education

Crucial features :

- Should integrate sustainable development concepts and content
- Should develop key competencies for sustainability
- Should truly matter and be relevant to the students



Pedagogical approaches :

- Learner-centred
- Action-oriented
- Multi-perspective
- Transformative Transgressive

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Example of integration of sustainability in a KTH course

MF2089 Challenge Driven Innovation for Sustainable Development 22.5 credits

Included in the Master's Programme, Integrated Product Design (TIPDM)

Intended learning outcomes

After passing the course, the students should be able to:

- Apply, critically evaluate and adapt working methods to handle challenge driven innovation projects connected to sustainable development
- Tackle complex (vague, ambiguous) innovation related challenges in a structured way
- …
- Justify innovation solutions and the choices that have led to the solutions, from both a value adding and a technical perspective
- Reflect about and promote sustainable development in innovation/product development work
- Develop skills in working in interdisciplinary and international project teams
- …

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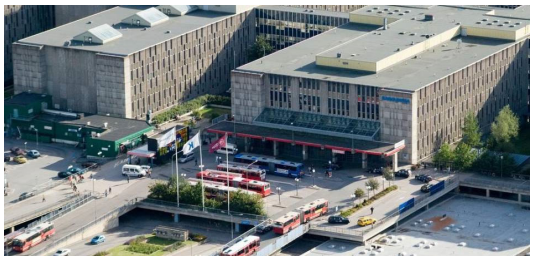
Example of integration of sustainability in a KTH course

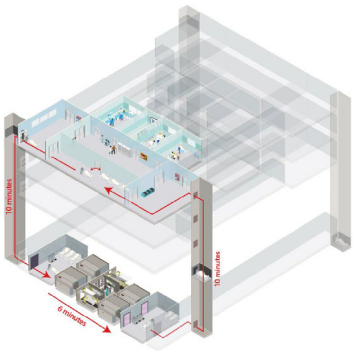
MF2089 Challenge Driven Innovation for Sustainable Development 22.5 credits

Included in the Master's Programme, Integrated Product Design (TIPDM)

Example of a challenge from a hospital in Stockholm:

- *7 % of the patients treated in Swedish hospitals suffer from Hospital Acquired Infections (HAI).*
- *In total 750 000 extra care days every year.*
- *20-40 % of nursing time is spent on cleaning instead of patient care.*
- *Great suffering for the affected patients.*





Solution developed by a multi-disciplinary team of students, including exchange students from Botho University, in terms of an *automated bed washing system.*

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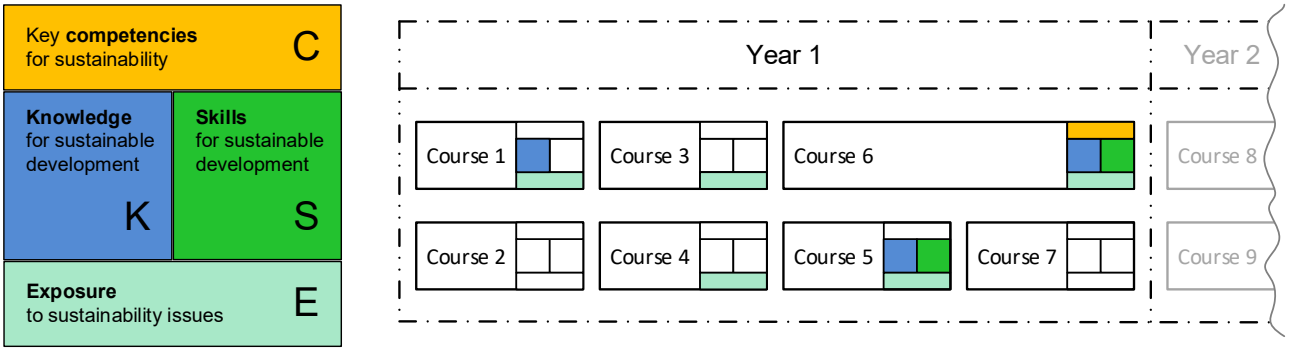
Simple framework for characterizing and guiding integration of sustainable development in courses and programs



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CDIO

A significantly more extensive framework
"*for producing the next generation of engineers*"

Created around 2001 by MIT, KTH, LiU, and Chalmers, as a response to critique from industry.

Now undergoing revision and updating, e.g. regarding sustainability, for maintaining its future relevance.

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CDIO

An idea of what engineering students should learn
- CDIO Syllabus (*engineers who can engineer*)

http://www.cdio.org/benefits-cdio/cdio-syllabus/cdio-syllabus-topical-form

A methodology for engineering education reform
- CDIO Standards

http://www.cdio.org/content/cdio-standards-30

A community for learning and sharing experiences

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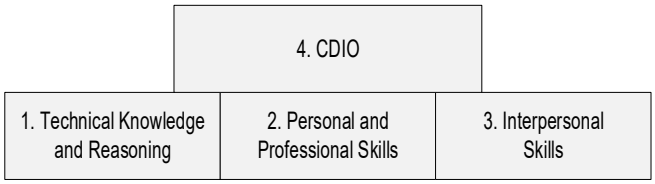
CDIO Syllabus



e.g.
2.1 ENGINEERING REASONING AND PROBLEM SOLVING
2.2 …
2.4 PERSONAL SKILLS AND ATTRIBUTES
- 2.4.1 Initiative and Willingness to Take Risks
- 2.4.2 Perseverance and Flexibility
- 2.4.3 Creative Thinking
- 2.4.4 Critical Thinking
  - The statement of the problem
  - Logical arguments and solutions
  - Supporting evidence
  - Contradictory perspectives, theories and facts
  - Logical fallacies
  - Hypotheses and conclusions
- 2.4.5 …

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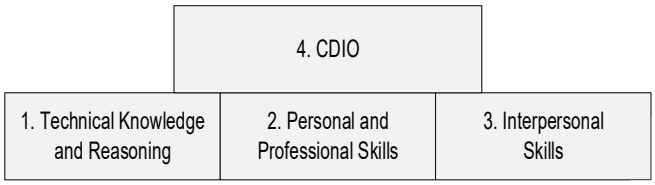
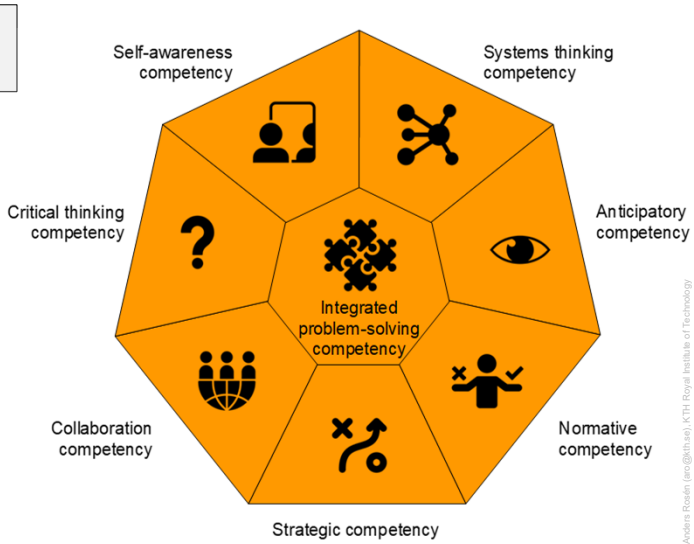
CDIO Syllabus – revision & updating 2018-2022



"Mapping the CDIO Syllabus to the UNESCO key competencies for sustainability"

Rosén, A., Edström, K., Grøm, A., Gumaelius, L., Munkebo Hussmann, P., Högfeldt, A-K., Karvinen, M., Keskinen, M., Knutson Wedel, M., Lundqvist, U., Lyng, R., Malmqvist, J., Nygaard, M., Vigild, M., & Fruergaard Astrup, T.,

Proceedings of the 15th International CDIO Conference, Aarhus, Denmark, June 25 – 27, 2019.



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CDIO Standards

Defining distinguishing features of CDIO programs in terms of a set of principles and good practices.

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).

In summary:

- A curriculum organized around mutually supporting courses, with *Conceive – Design – Implement – Operate* as context.
- Rich with student design-build-test projects.
- Integrating learning of professional skills such as teamwork and communication.
- Featuring active and experiential learning.
- Emphasizing faculty teaching competence.
- Constantly improved through quality assurance process with higher aims than accreditation.

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New complementary CDIO Standard for Sustainable Development

Defining distinguishing features of CDIO programs in terms of a set of principles and good practices.

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- Engineering education philosophy and aims (Standard 1);
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- Engineering projects and workspaces (Standards 5, 6);
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- Faculty development (Standards 9, 10);
- Assessment and evaluation (Standards 11, 12).

→

New complementary CDIO standard for sustainable development

+ The program emphasizes environmental, social and economic sustainability in the adoption of the CDIO principles as the context for engineering education

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New complementary CDIO Standard for Sustainable Development

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- Assessment and evaluation (Standards 11, 12).

→

cont.

+ Sustainability related knowledge, skills and attitudes, are explicitly addressed in program goals and learning outcomes.
+ Aspects of sustainability 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.

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- Teaching and learning methods (Standards 7, 8);
- Faculty development (Standards 9, 10);
- Assessment and evaluation (Standards 11, 12).

cont.

+ 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, retirement, etc., of existing technology.
+ Physical and digital learning environments enable interdisciplinary and transdisciplinary collaborative learning and interaction with various external stakeholders

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- Faculty development (Standards 9, 10);
- Assessment and evaluation (Standards 11, 12).

cont.

+ Sustainability learning experiences are integrated with the learning of disciplinary knowledge, personal and interpersonal skills, and product, process, system and service building skills.
+ Active experiential and transformative learning activities develop students' key competences for sustainability.

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New complementary CDIO Standard for Sustainable Development

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- Faculty development (Standards 9, 10);
- Assessment and evaluation (Standards 11, 12).

cont.

+ Enhancement of faculty competences for sustainability and related teaching competences is actively promoted.

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New complementary CDIO Standard for Sustainable Development

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12 “core” standards:

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- Teaching and learning methods (Standards 7, 8);
- Faculty development (Standards 9, 10);
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cont.

+ 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.

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New complementary CDIO Standard for Sustainable Development

Levels of fulfilment:

Level	Criteria
0	There are no sustainable development learning experiences in the program.
1	**Minor** sustainable development learning experiences have been are implemented in at least **one course** and needs and opportunities for extended integration of sustainable development have been identified.
2	At least **two** sustainable development learning experiences, where at least **one** is **substantial**, are being implemented and there is a plan for extended integration of sustainable development.
3	There are **explicit program goals** and intended learning outcomes considering **knowledge as well as skills** related to **environmental**, **social** and **economic** aspects of sustainability, and students learning towards these goals and outcomes are supported by at least **four** sustainable development learning experiences, where at least two are substantial, including an **introduction early in the program**.
4	The integration of sustainable development is pervasive, well adapted to the program context, promoting progression of knowledge, skills, attitudes, and key competencies for sustainability, and there is documented evidence that students have achieved the related intended learning outcomes.
5	Sustainable development is fully integrated in accordance with the description in the optional CDIO standard for sustainable development.

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KTH's sustainability objectives for education 2016-2020

In summary:

Sustainable development shall be integrated into all educational programs at all levels so that students can contribute to the sustainable development of society after graduation.

Övergripande mål för utbildning 2016-2020:

- KTH ska öka alla anställdas och studenters kunskap om och engagemang i frågor gällande hållbar utveckling.
- Hållbar utveckling ska vara integrerat i alla utbildningsprogram på samtliga nivåer så att studerande efter examen kan bidra till en hållbar samhällsutveckling.

Hållbar utveckling ska integreras i KTH:s samtliga program, inklusive forskarutbildningen. Det ska också finnas utbildningsprogram på alla nivåer som har fokus på hållbarhetsfrågor. På alla arkitekt-och civilingenjörsprogram ska det finnas en möjlighet att få en hållbarhetsprofil på sin utbildning genom valbara kurser eller möjlighet att välja ett masterprogram eller spår med hållbarhetsfokus. Kopplat till miljöledningssystemet ska skolorna upprätta handlingsprogram för hur integrering av hållbar utveckling i utbildningsprogrammen ska stärkas. Detta kan om möjligt ske integrerat med programutvecklingsplaner. Vid centrala uppdrag och utredningar med koppling till utbildning ska hållbar utveckling integreras i arbetet. En pedagogisk kurs i Lärande för hållbar utveckling ska ges minst årligen. Seminarier och nätverksträffar för undervisande personal ska ordnas. KTH ska ge anställda och studenter kunskap och medvetenhet om hållbar utveckling i det dagliga arbetet och studielivet. KTH ska erbjuda både allmänna breda utbildningar för alla anställda och specifika utbildningar där behov finns, exempelvis inom kemikaliehantering. I kommande kvalitetsutvärderingar ska hållbar utveckling ingå.

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KTH's sustainability objectives for education 2016-2020

Evaluated in 2020
in relation to the CDIO Standard for Sustainable Development and other instruments.

KTH:s hållbarhetsmål för utbildning

Uppföljning av målperioden 2016-2020

Hélène Hermansson & Anders Rosén

2021-02-09

KTH

EXPERIENCES FROM APPLYING THE CDIO STANDARD FOR SUSTAINABLE DEVELOPMENT IN INSTITUTION-WIDE PROGRAM EVALUATIONS

Anders Rosén, Hélène Hermansson, Göran Finnveden, Kristina Edström

KTH Royal Institute of Technology, Stockholm, Sweden

ABSTRACT

KEYWORDS

INTRODUCTION

Providing input for formulating KTH's new sustainability objectives…

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KTH's sustainability objectives for education 2021-2025

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.

Vxe0wdujhwvwr eh dfklhyhg e| wkh hqg ri5358 dwwkh qdwhvw
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 3 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.

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Evolution or revolution: What is required for reaching a future relevant engineering education?

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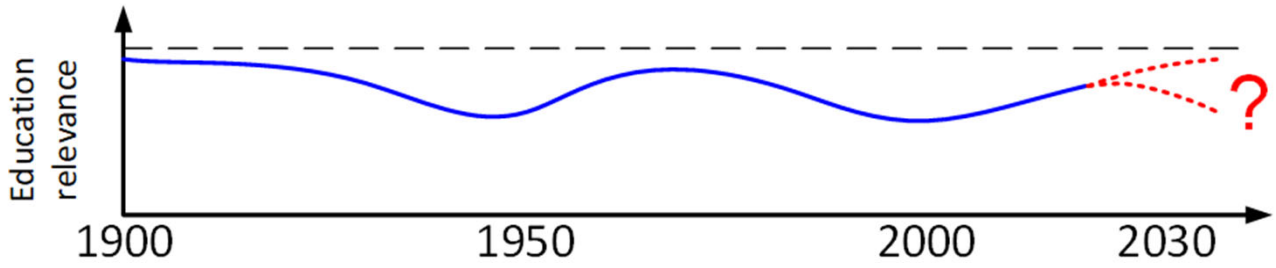
Engineering education evolution



Engineering = art & craft (+ little science)

Technical systems increasingly advanced and complex

Increasing gap between the teaching of engineering sciences and real engineering practice

1st engineering education reform:
- ✔ enhancing the scientific basis

2nd engineering education reform:
- ✔ outcomes oriented
- ✔ student centred
- ✔ PBL
- ✔ CDIO
- ✔ industry relevance

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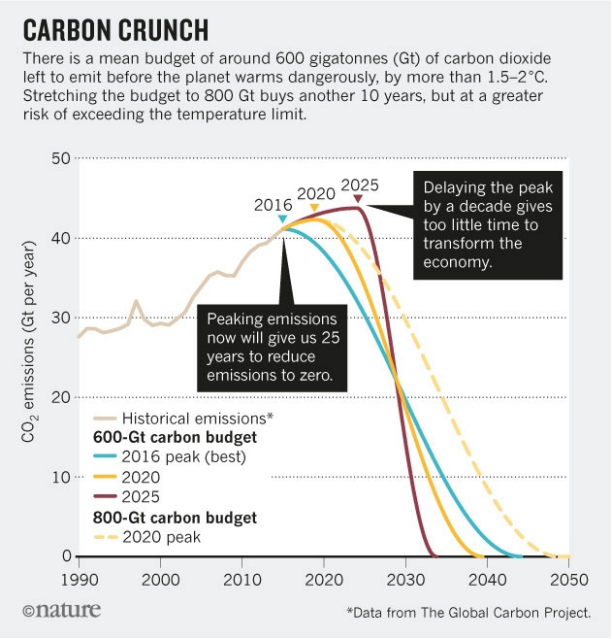
One of several crises we are facing



https://www.nature.com/news/three-years-to-safeguard-our-climate-1.22201

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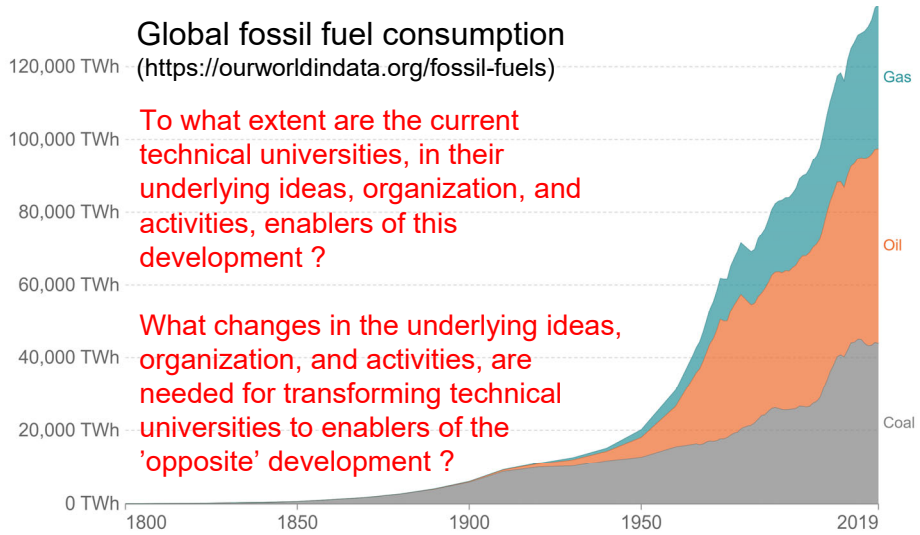
Future relevance of current engineering educations ?



To what extent are the current technical universities, in their underlying ideas, organization, and activities, enablers of this development ?

What changes in the underlying ideas, organization, and activities, are needed for transforming technical universities to enablers of the 'opposite' development ?

École Polytechnique 1794

Mekaniska skolan 1798

Humboldt-Universität zu Berlin 1810

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Some perspectives from Lotz-Sisitk et al (2015)…

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Some perspectives from Lotz-Sisitk et al (2015):

Different options for universities' sustainability engagements

1. Denial
   - it's a hype that will go away
2. Bolt on
   - add a 'green aspect' to a curriculum or programme
3. Built-in
   - important enough to integrate in all we do
4. Whole system re-design
   - a paradigm shift, re-think the very foundations of what we currently do, a transition towards doing better things differently (transformation) rather than doing what we do better (optimization)

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Some perspectives from Lotz-Sisitk et al (2015):

Transdisciplinary barriers & opportunities

Sustainability challenges are *'wicked problems'*, i.e. *coupled social–ecological systems*, that can only be fully understood and engaged through transdisciplinary approaches involving multiple actors.

However, mono-disciplinarity and mono-sectoral practice remain dominant.

45

Some perspectives from Lotz-Sisitk et al (2015):

Transdisciplinary barriers & opportunities

The disciplines were developed in the strive to colonize reason and maximize rationality.

Disciplinary decadence is the turning away from reality to a 'deontologised' or absolute conception of disciplinary life, where the discipline becomes THE world which is regulated by its internal methodology and rules.

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Some perspectives from Lotz-Sisitk et al (2015):

Transdisciplinary barriers & opportunities

Significant for transformative, transgressive forms of thinking and pedagogy is that *teleological suspensions of disciplines* are also *epistemic decolonial* acts, i.e. transgressing taken-for-granted norms.

Conflicts and synergies between different socio-technical sustainability transition ontologies and epistemologies (Geels 2010).

47

Some perspectives from Lotz-Sisitk et al (2015):

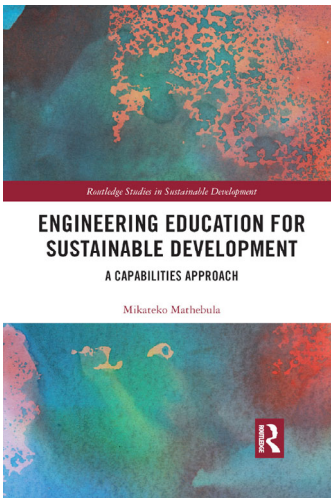
Transformative, transgressive learning shaped by

1. the capabilities approach (reflexive social learning and capabilities theory)

Normative approach to human welfare that concentrates on the actual capabilities of persons to achieve their well-being rather than on their mere right or freedom to do so.

Changes the focus from means (the resources people have and the public goods they can access) to ends (what they are able to do and be with those resources and goods) – 'real freedom', 'flourishing'.

Views transformative and transgressive learning as one of several intrinsic values to human well-being.



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Some perspectives from Lotz-Sisitk et al (2015):

Transformative, transgressive learning processes influenced by

2. critical phenomenology

Overcoming the crippling dualisms of Western modernity.

Phenomenological experiences of learners providing opportunities for inquiry that does not separate object and subject or place and person.

Place- and inquiry-based learning in direct encounters with communities, leading to democratic participation and social action.

Adding flesh and life to the bones so often polished smooth and white by analytical thought.

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Some perspectives from Lotz-Sisitk et al (2015):

Transformative, transgressive learning processes influenced by

3. socio-cultural and cultural historical activity theory

How learning can lead development and enable someone to become what they are not yet and that communities can similarly transform their activity through expansive learning.

A view of culture as aspirational and open to systemic change and transformation.

Emergence of new forms of agency including resistance, critique, reframing, envisioning, committing to actions, navigating power relations and taking transformative action.

Increasing cognitive justice.

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Some perspectives from Lotz-Sisitk et al (2015):

Transformative, transgressive learning processes influenced by

4. new social movement, postcolonial and decolonisation theory

If any teaching is to be done it should emphasize the struggles for an equal and just society and a dignified life. One cannot search for emancipatory inspiration in past or present idealized cultures, but only in the exceeding of culture through the contradictions which it itself engenders.

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what if…

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What if
engineering education
was about
the common good...

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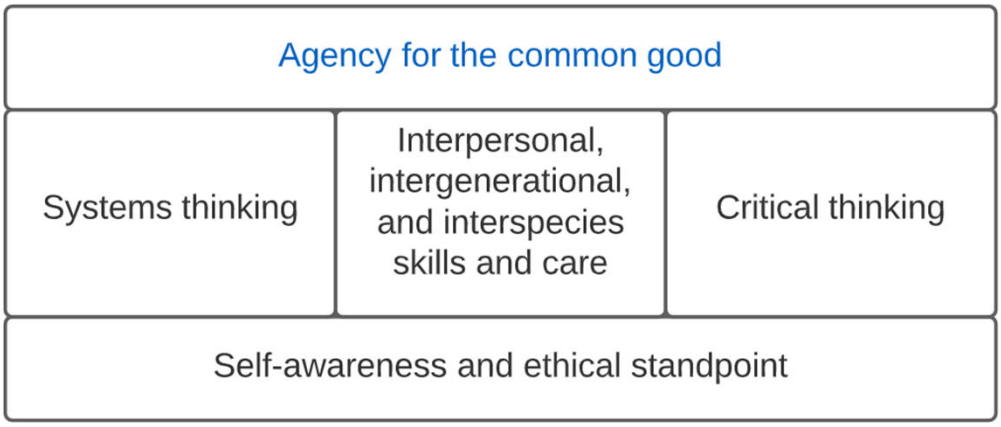
What if learning was centered around
key competencies...

(rather than subjects and disciplines)



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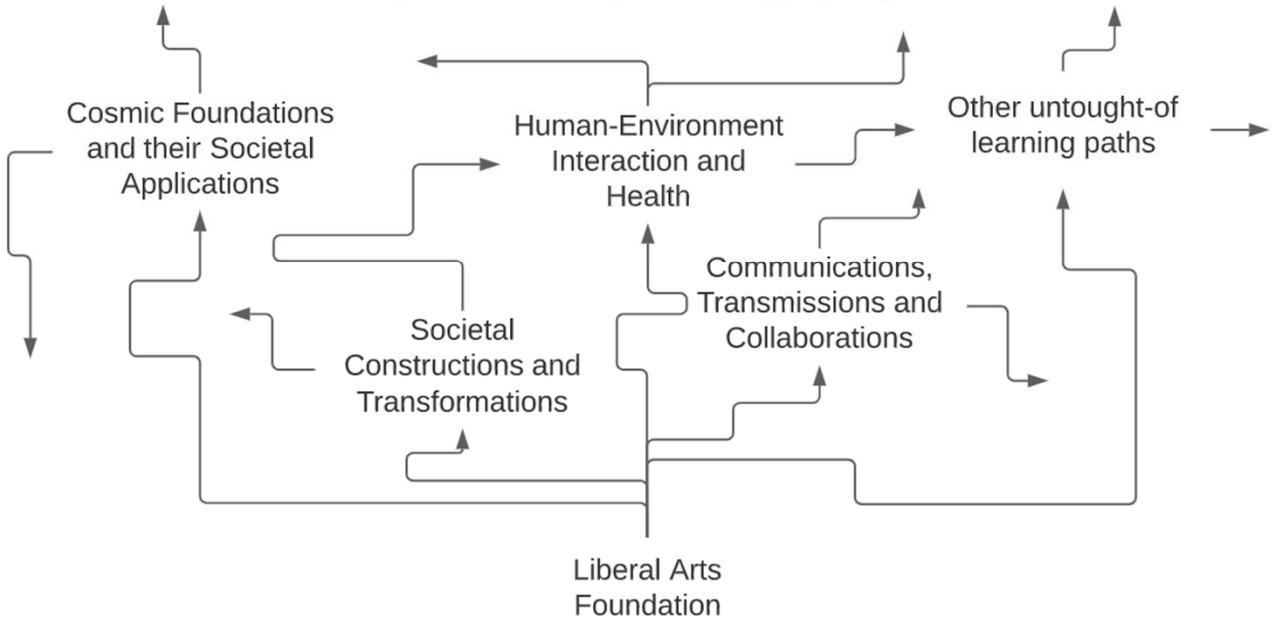
What if students were creating and exploring learning paths...

(rather than choosing and following programs)



55

What if students were...

...operationalizing knowledge and skills and developing key competencies while contributing to sustainable transformations of society through a series of co-creative *challenge-driven projects*

...learning basic knowledge and skills through online *self-study modules*

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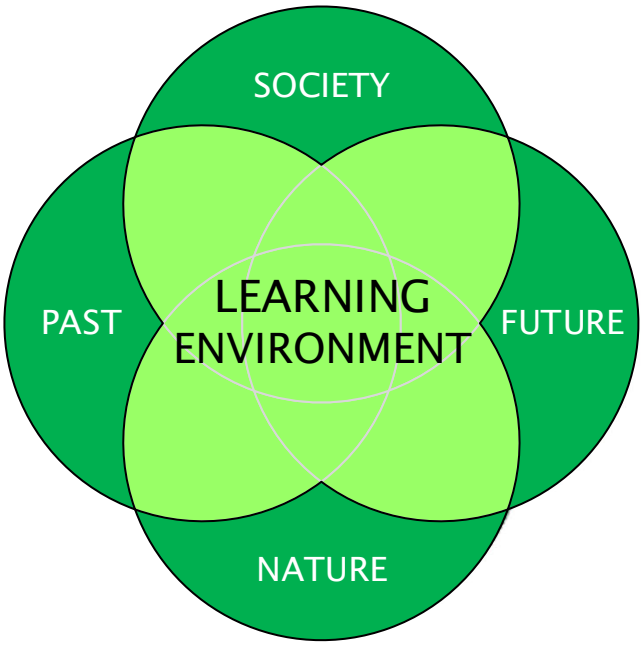

What if learning was taking place in the intersection between society, nature, past, present, and future...

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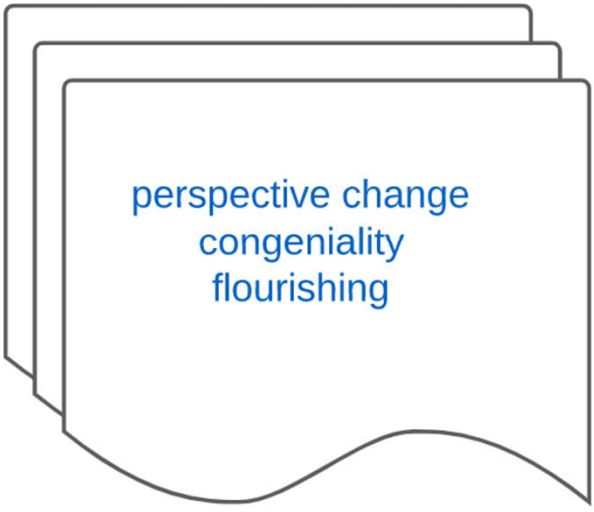
What if assessment & certification was about...



(rather than proficiency level)

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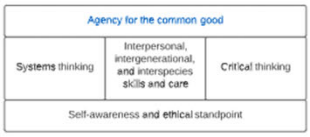
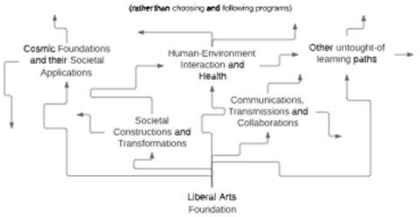
What kind of engineers would come out from that?

What if engineering education was about the common good...

What if learning was centered around key competencies...
(rather than subjects and disciplines)



What if students were creating and exploring learning paths...
(rather than choosing and following programs)



What if assessment & certification was about...

What if learning was taking place in the intersection between society, nature, past, present, and future...

What if students were...

What kind of society would they shape?

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