A strategy and an example to increase sustainability at KTH

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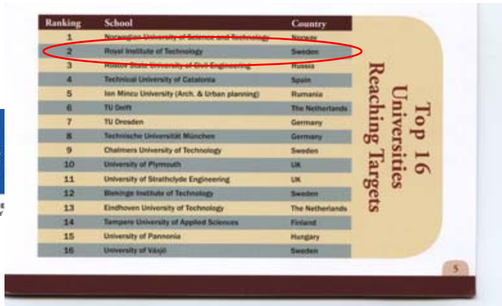
KTH, the Royal Institute of Technology
Excellence in Education, Research and Entrepreneurship

KTH has a SD reputation to live up to:



Ranking	School	Country
1	Norwegian University of Science and Technology	Norway
2	Royal Institute of Technology	Sweden
3	Rostov State University of Civil Engineering	Russia
4	Technical University of Catalonia	Spain
5	Ion Mincu University (Arch. & Urban planning)	Rumania
6	TU Delft	The Netherlands
7	TU Dresden	Germany
8	Technische Universität München	Germany
9	Chalmers University of Technology	Sweden
10	University of Plymouth	UK
11	University of Strathclyde Engineering	UK
12	Blekinge Institute of Technology	Sweden
13	Eindhoven University of Technology	The Netherlands
14	Tampere University of Applied Sciences	Finland
15	University of Pannonia	Hungary
16	University of Växjö	Sweden

Results from 2006 ranking in ”Status in engineering education for sustainable development (EESD) in European higher education” published by *The Alliance for Global Sustainability.*

…KTH has work to do!

Results from 2006 ranking in ”Status in engineering education for sustainable development in European Higher education” *The Alliance for Global Sustainability.*

Increasing Sunstainability on campus is:

- A strategic issue
- A management problem
- A pedagogical challenge
- A tecnical challenge
- An economic dilemma (from first cost to LCC thinking for example)
- Etc…

Our philosophy…

- At any given point in time there are many things that can be done to improve sustainability at campus. These are the **”field of options”.**
- There are moments in time when the freedom (or pressure) to do change is much bigger; “large” decisions have to be taken. A **“situation of opportunity”** arise for a short window of time.
- Thus, an **“Early Warning System”** for SD must be created to foresee future possibilities (this presentation is part of the EWS!)

Current "Situations" at KTH

- Dynamic Infrastructure, new housing, departments are pushed/move around
- New organization at KTH
- Centre for SD started this spring (initiating several new projects) including ZEH - zero emission house project.

- Bologna process: 3+2 year curricula (B.Sc/M.Sc) from fall 2007 → Programs are changed!
- New national directive for higher education
- New national validation criteria to meet (incl. SD)
- Pull from students and society
- Ongoing Pedagogical revolution: "From teaching to learning…"

Case study chosen here: Integration of SD in all engineering curricula at KTH (2007-2009)

Method: Develop contextual (intended) learning outcomes (LO) for SD explicit for all courses in programs

Process: Benchmarking SD today →negotiating and setting new program goals →developing LO´s →course mapping and development → implementation → follow up →"Green program awards" 2009

Background: Sociecty needs a new kind of engineer

Present focus

- Context: Engineering science
- Reduced, "pure" problems (with right and wrong answers)
- Design phase
- Individual effort

Desired focus

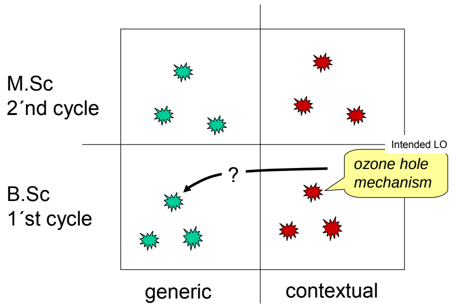
- Context: product and system development (products and systems
- in a wide sense including generic and
- contextual SD
- Systems view, problems go across disciplines, are complex and ill-defined, and contain environmental, societal and business aspects
- Understand the whole cycle: Conceive, design, implement, operate
- Teamwork, communication

A modern curricula must therefore adress a long list of desired competences.

1. Technical
2. Scientific
3. Personal/Interpersonal
4. CDIO: Conceive - Design - Implement – Operate*) Systems in the societal, environmental and business context, i.e. SD

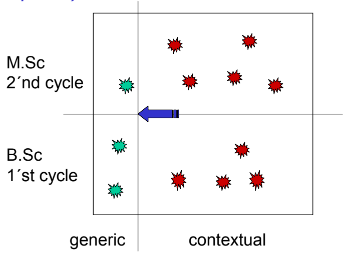
*)The CDIO Syllabus is available at www.cdio.org

Chosen structure to classify and select aspects of SD in educational programs



Why integrate these "generic skills" into technical courses?

*Because we belive that Competence in Sustainable development is **context-dependent** and should be learned and assessed in the (appropriate) technical/scientifical context.*



Constructive Alignment (Biggs 1999)

1. Program goals in SD

2. Intended Learning outcomes

What should the student be able to do with respect to SD as a result of the particular course?

Integration of SD competencies into:

Objectives

Activities

Assessment

3. Designing activities

4. Designing assessment

What work is appropriate for the student to do to reach the intended LO´s?

What should the student do to demonstrate that they reached the intended LO´s?

The basic idea: Systematic integration of competencies

Development routes (schematic)				
Year 1	Introductory course	Physics	Mathematics I	
	Mechanics I	Mathematics II	Numerical Methods	
Year 2	Mechanics II	Solid Mechanics	Product development	
	Thermodynamics	Mathematics III	Fluid mechanics	Sound and Vibrations
Year 3	Control Theory	Electrical Eng.	Statistics	Signal analysis
	Sustainable development	Communi-cation	Project management	Teamwork

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Black box coordination exercise

INPUT:

Previous knowledge and skills → Course (here: black box)

OUTPUT:

→ Input to later course i
→ Input to later course ii
→ Input to later course iii etc.
→ Final competence

- All courses in the program are presented through their input-output only
- The black box approach enables efficient discussions
- Makes connections visible (as well as lack thereof !)
- Serves as a basis for improving coordination between courses
- Helps faculty learn about the program as a whole

Sustainability of educational change

- Today we must keep applying force in the system (leadership, resources) to keep the programs from reverting to the ”natural state”.
- Thus we are operating under the principle: *With enough thrust, anything can fly*.”

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Where the rubber meets the road

- The way the **system** works:
  - how the university is organized,
  - how recruitment & promotion processes are designed,
  - how power is assigned,
  - how resources are allocated,
  - and how status is earned,
  - (what matters to people, the real, hard, end-of-the-day, bottom-line stuff)

is probably shaped to accommodate the disciplines and research, rather than education or student needs.

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Sustainability of educational change

- KTH has so far **proved willing** to take SD seriously and **several new activities** are underway in curricula development, improved campus area, a Centre for SD and other routines. It is today ”projects” but it must be developed into **steady state**.
- In the long run, we may therefore have to **change the system itself** so it is **aligned** - not only with disciplines & research - but also **with the educational experiences we want to create**.

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Credits

- Nils Brandt, Industrial Ecology
- Kristina Edström, KTH Learning Lab
- Anna-Carin Högfeldt, KTH LL

The implementation process

1. **Benchmarking (spring 2007):**
Review of program goals
Strategy documents
Existing LO´s for courses
Self evaluation
Identification of contextual examples of LO´s within each program

Starting point I: Existing curriculum (self evaluation)

What SD competences (generic and contextual) are already addressed in program courses?

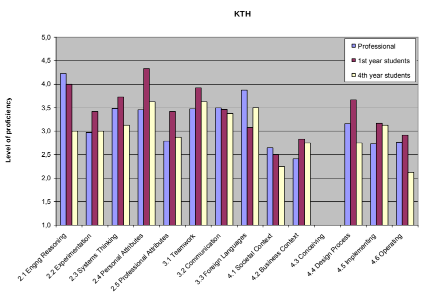
- The existing curriculum is benchmarked thorugh self asessment + expert team
- The ”program owners” are asked to select examples of contextual SD issues
- Follow up **interviews** with faculty members responsible for a specific course in the program

Starting point II: Program planning/Validation (fall 2007)

What SD competences (or other comptences expressed through the CDIO Syllabus) should be prioritized *in this program*?

- Validate plans with all stakeholders
- Setting program goals in SD
- This is made through surveys to alumni, students, industry
- Comparisons with accreditation / regulations etc
- Discussions in faculty

Survey example: KTH



[Benchmarking Engineering Curricula with the CDIO Syllabus. Bankel et al. (2005) *The International Journal of Engineering Education*, Vol. 21 No. 1, 2005.]

An example already implemented

Communication **in engineering** means being able to

- use the technical concepts comfortably,
- discuss a problem at different levels,
- determine what is relevant to the situation,
- argue for or against conceptual ideas and solutions,
- develop ideas through discussion and collaborative sketching,
- explain the technical matters for different audiences,
- show confidence in expressing yourself within the field...

Communication skills as contextualized competences are **embedded** in, and **inseparable** from, students' application of technical knowledge.

The same kind of reasoning can be made for sustainable development, teamwork, ethics (etc...) as well.

Synergy effects

2. Practising competence in SD **in** the disciplinary context means expressing and applying technical knowledge. Training for competence in SD will therefore at the same time reinforce students' understanding of disciplinary content – they will acquire a **deeper working** knowledge of engineering fundamentals.

   – *"I can't see that a credit of writing reports in my course is a wasted credit. Writing reports is an appropriate learning activity in my subject."*
   (Claes Tisell, KTH Machine design)

3. Engineering faculty are engineering role models and we must **show commitment** by involving ourselves.

Plan for systematic integration

Development routes (schematic)				
Year 1	Introductory course	Physics	Mathematics I	
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Year 2	Mechanics II	Solid Mechanics	Product development	
	Thermodynamics	Mathematics III	Fluid mechanics	Sound and Vibrations
Year 3	Control Theory	Electrical Eng.	Statistics	Signal analysis
	Oral presentation	Report writing	Project management	Teamwork

Faculty perception of skills

Place in curriculum	Perception of generic graduate skills and attributes
Integral	They are integral to disciplinary knowledge, infusing and **ENABLING** scholarly learning and knowledge.
Application	They let students make use of or apply disciplinary knowledge, thus potentially changing and **TRANSFORMING** disciplinary knowledge through its application. Skills are closely related to, and parallel, discipline learning outcomes.
Associated	They are useful additional skills that **COMPLEMENT** or round out discipline knowledge. They are part of the university syllabus but separate and secondary to discipline knowledge.
Not part of curriculum	They are necessary basic **PRECURSOR** skills and abilities. We may need remedial teaching of such skills at university.

[Simon Barrie 2002, 2004]

Levels of commitment

- **Introduce** (I):
  - the topic is treated in some way in the course, but
  - it is not assessed, and
  - probably not mentioned in the course objectives.
- **Teach** (T):
  - there is an explicit course objective,
  - and it is part of a compulsory activity,
  - students get to apply and get feedback on their performance (usually in assessment).
- **Utilize** (U):
  - it is applied in a compulsory activity, but
  - mainly to achieve or assess other objectives in the course.

Course development phase

1. Create new courses or retask existing ones
   - build on existing strengths (consolidate & develop existing learning activities)
   - work with faculty who are willing & able
   - invite proposals rather than give orders
2. Supporting the development
   - increase number of credits for new responsibilities?
   - allocate resources for course development, give individual support
   - allocate resources for faculty development: individual support, workshops etc

- Remember that we are developing the people as much as we are developing the programme

New design-build project course

Task 2002: Design, build and fly a solar powered aircraft that can take 2 kg payload...

"Deep learning is associated with doing. [...]

Doing is not sufficient for learning, however.

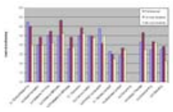
Learning activity must be planned, reflected upon and processed, and related to abstract conceptions."

[Graham Gibbs (quoting John Biggs) in Gibbs 1992]

Quote from a student in design-build course

- *You knew theories [about teamwork] before. These things are so easy to say, empty phrases. But now I have seen them in reality. Like '...'. I mean, you don't have to be a rocket scientist to realise that, everyone knows it. It is so obvious, you can stop anyone on the street and they would say 'of course, everyone knows that'. But it's one thing to know and another thing to apply, and we really got first-hand experience from applying it. It is a completely different thing to experience it in reality*.

Process overview



1a. Validation with stakeholders

1b. Benchmarking of existing courses (interviews) and self asessment

2. Mapping of SD and other skills such as entrepreneorship to existing and new courses

3. Course development

4. Fine-tune coordination