KTH ROYAL INSTITUTE
OF TECHNOLOGY

Welcome!

Enhancing Engineering Education, EEE2017

Introductions
Monday, Oct 16th

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Margareta Bergman
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is **DIRECTOR OF STUDIES** and administrative **COORDINATOR.**
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INTRODUCTIONS

1. 

Ahmed Elsabbagh
Mohamed Abdelaziz
Mohamed Sheirah
Tamer Elnady

2. 

Eunice Ja Young Kim
Eunju Jung

3. 

Chinandu Mwendapole
Suresh Shanmugasundaram
Venkataraman Vishwanathan

4. 

5 

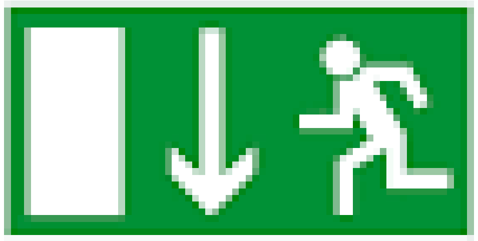
Larisa Bugaian   Valentina Pritcan
Dinu Turcanu   Natalia Gasitoi
Otilia Dandara   Mariana Spatari
Natalia Zamfir   Victoria Rotaru
Liliana Turcan   Rodica Bugai
Liudmila Rosca-Sadruschi
Andrei Popa

TEAM WORK WITH YOUR PEERS AT THE TABLE

PLEASE SHARE AND DISCUSS YOUR EXPECTATIONS ON EEE2017

- Please find out more about your peers around the table
- Common challenges and improvement areas
- While here at KTH, with colleagues from five countries, what questions/experience do you have that you would like to discuss and reflect upon?

”SAFETY FIRST, THEN FUN”



Welcome to KTH!

Research and education for a brighter tomorrow

KTH rests on three pillars; ***sustainability*, *equality* and *internationalisation*:**

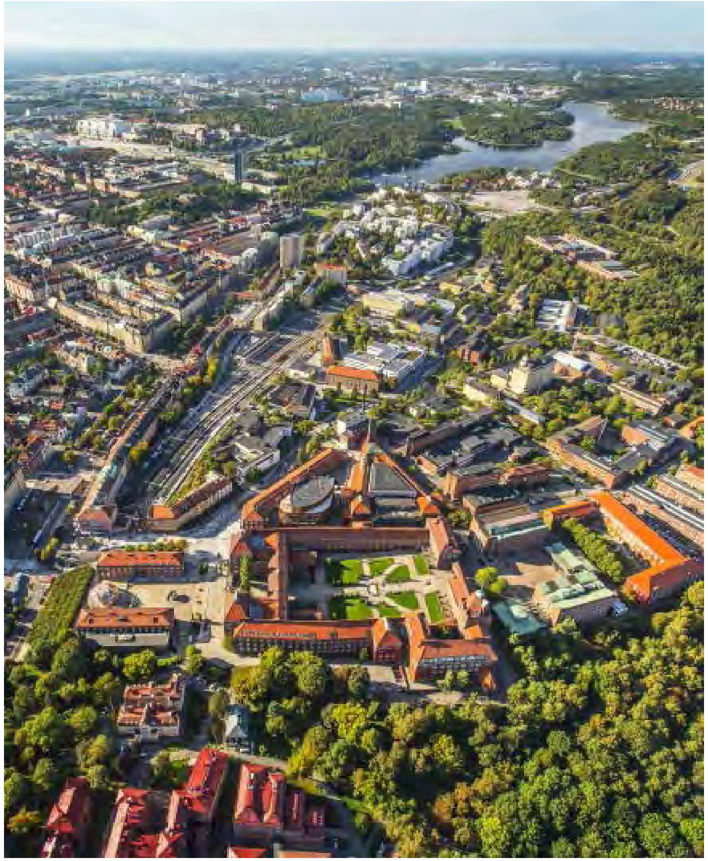
- We are working proactively for a more sustainable future.
- For us, gender balance is about equality, as well as quality of learning, research and results.
- We are home to students, researchers and faculty from around the world - all dedicated to advancing knowledge.

Sigbritt Karlsson,
KTH President

Students and employees

Sweden's largest technical research and learning institution:

- More than 13,000 full-time students (one-third women).
- Close to 1,800 research students (one-third women).
- Around 3,500 full-time positions (one-third women).
- Four campuses in the Stockholm region.



Education at KTH

Nurturing minds and shaping things to come

Excellence demands an extraordinary education; students deserve the best conditions to succeed in their studies.

Focusing on practical application of higher learning.

Active cooperation with top universities around the world.

Programmes at KTH

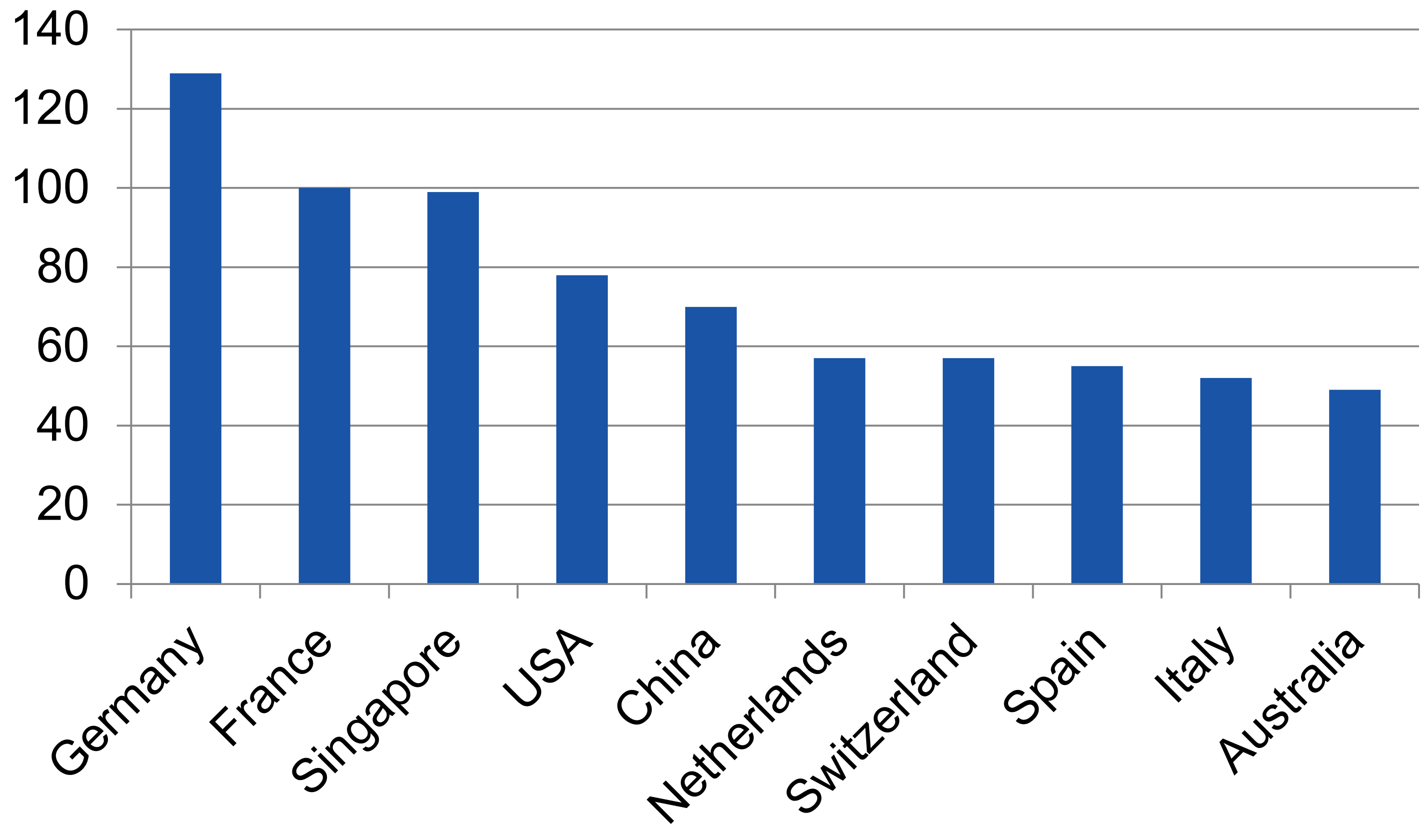
The following degrees are awarded:

- *Bachelor of Science in Engineering*
- *Master of Science in Engineering*
- *Master of Architecture*
- *Master of Science in Engineering and Education*
- *Licentiate*
- *Ph.D.*

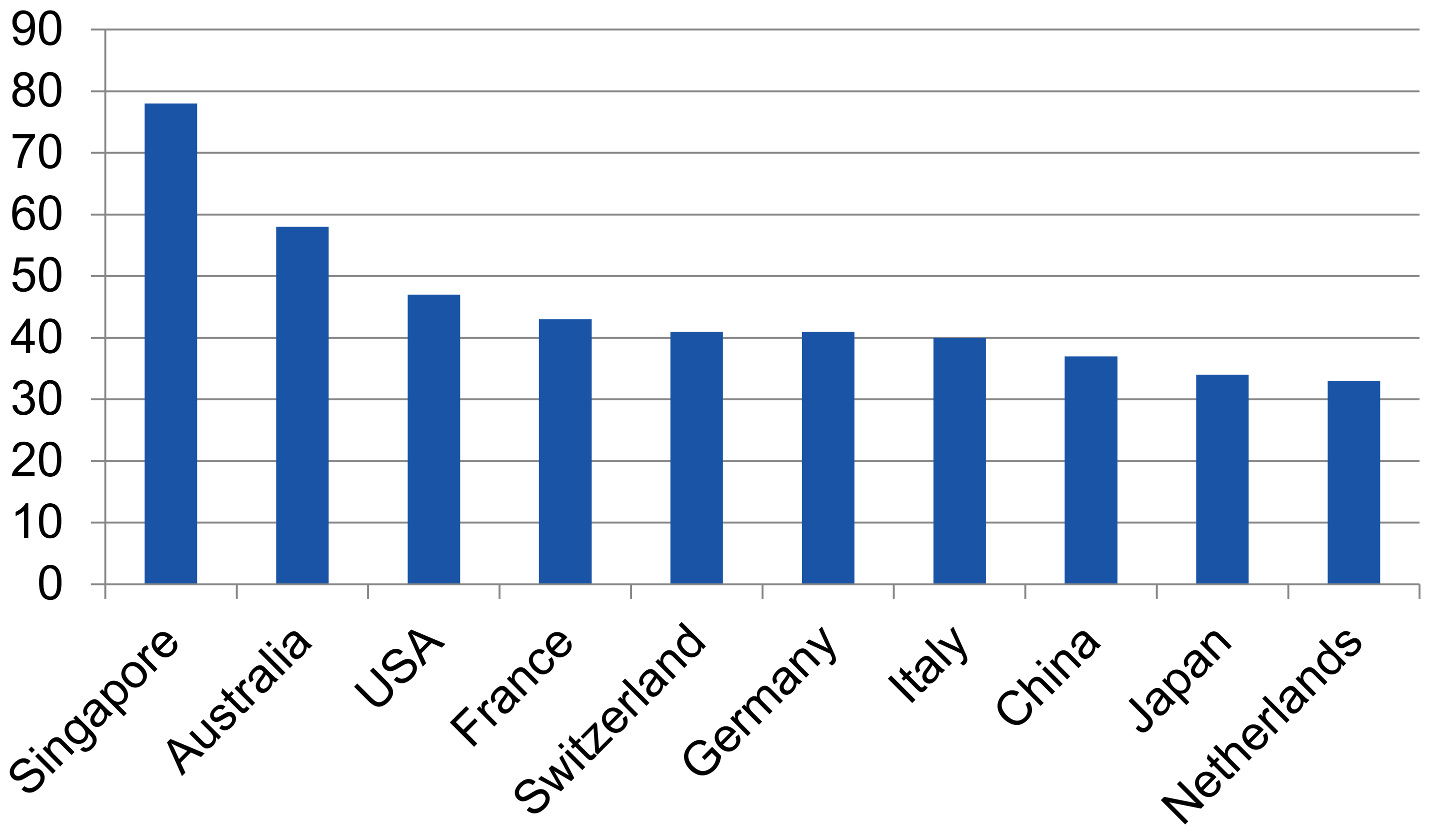
Over 60 Master's programmes are offered in nine fields.

Programmes have links with research and industry.

Inbound students



Outbound students



GUIDING PRINCIPLES FOR THE ENHANCEMENT OF ENGINEERING EDUCATION

Professional Education
– not preparing well enough for the ”swamp” of complexities in real-life?

“The schools view teaching as transfer of information; learning as receiving, storing and digesting information. ‘Knowing that’ tends to take priority over ‘knowing how’.”

Schön, Donald A. "Educating the reflective practitioner." *San Francisco* (1987). P.309.

A disaster nurse on the expectations of an engineer: on the ”swamp” of complexities in real-life

”Creating relationships and building teams, making decisions based on so much input you can get and telling them right, talking to authorities and media … well, caring about the whole situation”

Modernization of Higher Education Teaching and Learning in Theory

At KTH, a crucial engine and focus has been the CDIO framework

Explained deeper this afternoon and exemplified tomorrow

Behaviorism
Cognitivism

Constructivism

Social learning

Learning as both a personal and social process.

Development of technologies (access, time, distance)

Motivation of learners: high level of interaction and activity.

Employers expect relevant skills .

Scaffolding/feedback from different sources/people/experts/society

Community of learners from geographically diverse locations, develop multidisciplinary solutions. Communication, interaction, diversity

SOCIAL CONSTRUCTIVISM, SITUATED LEARNING, MOBILE LEARNING, CONNECTIVISM…
(Ertmer & Newby, 2013)

- Profession & business
- Societal context
- Problem formulating & Designing
- Integrative
- Distributed knowledge and experience
- Specialists in collaboration
- Team & Individual
- Value-driven

Learning as both a personal and social process.

Development of technologies (access, time, distance)

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SOCIAL CONSTRUCTIVISM, SITUATED LEARNING, MOBILE LEARNING, CONNECTIVISM…
(Ertmer & Newby, 2013)

Educational change

Curriculum development (programs, courses, module)

- Learning outcomes, activities and assessment procedures
- Linking, connection, progression
- Quality assurance and enhancement procedures

Faculty development

- Knowledge
- Skills
- Values

Organization / Institutional development

- Physical infrastr
- Social infrastr
- Organizational infr.

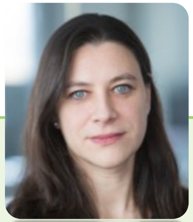
Student development

- Democracy, influence
- Values and attitudes
- SCL
  Self Regulated Learning
  Meta Learning,

Monday.

13.15–16.00	**CDIO – the Idea, Methodology and Community**
17.00 – 19.00	Welcome reception In KTH President office building. **Venue Brinellvägen 8 11th floor**

Tuesday.

09.15–12.30	**Integration of sustainable development**
13.30 – 16.00	**Workshop: level of integration** Characterization of the level of integration of sustainable development in engineering educational programs and/or correlated courses

Wednesday.

09.15–12.00	Visiting a program
13.15 – 16.00	The Teaching Trick – How to improve student learning without spending more time teaching

Thursday.

09.15–12.00	**How to improve student learning in lectures – Peer instruction** ***Venue Brinellvägen 28A second floor, Room U21.***
14.00 – 16.00	**Workshop: Strategies for change**
16.00	Lab tour

Friday.

09.15–12.00	Designing and organizing blended courses	
13.15 – 16.00	Roundup meeting	

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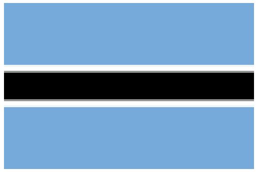

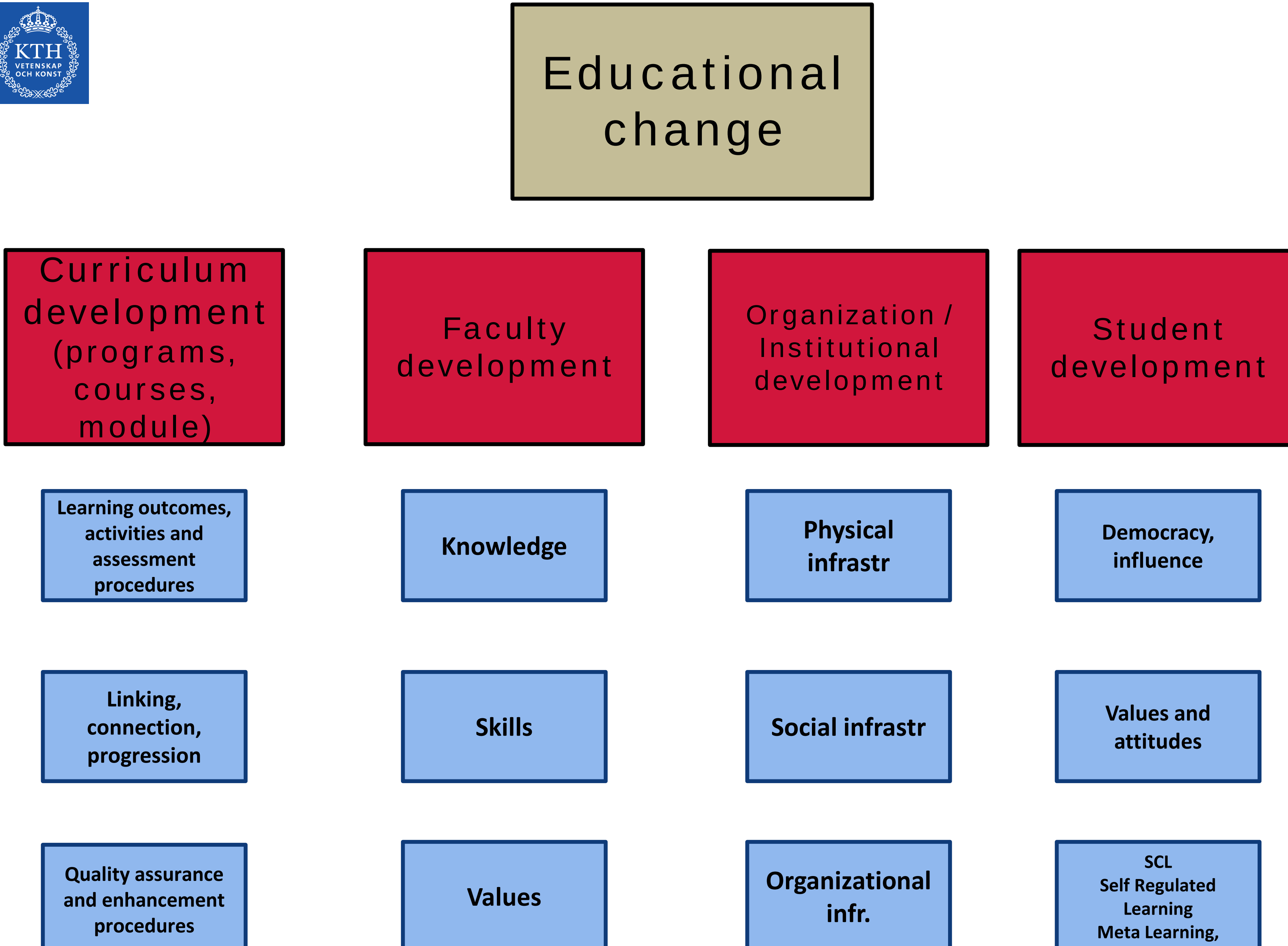
Educational change
Curriculum development (programs, courses, module)
Faculty development
Organization / Institutional development
Student development
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SCL
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Meta Learning,

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KTH
VETENSKAP
OCH KONST

STRATEGIES FOR CHANGE

Curriculum, Faculty, Organization and Students With a Shared Perspective – Desirable and Possible?

ANNA-KARIN HÖGFELDT Director of Factulty Development Program, Department of Learning

ELISABET LÖVQVIST Head of Educational Affairs, Student Union at KTH

Educational change

Curriculum development (programs, courses, module)	Faculty development	Organization / Institutional development	Student development
Learning outcomes, activities and assessment procedures	Knowledge	Physical infrastr	Democracy, influence
Linking, connection, progression	Skills (eg discussing learning, collaborating)	Social infrastr	Values and attitudes
Quality assurance and enhancement procedures	Values	Organizational infr.	SCL Self Regulated Learning Meta Learning,

Example: Society needs engineers who can build a sustainable society

Curriculum development (programs, courses, module)

- UN goals
- National goals
- "Self evaluation" for all programs in year 2012 and 2016

Faculty development

- Faculty training course: *Learning for Sustainable Development, LH215V*
- Toolbox for teachers online with best practice
- National and international networks and conferences

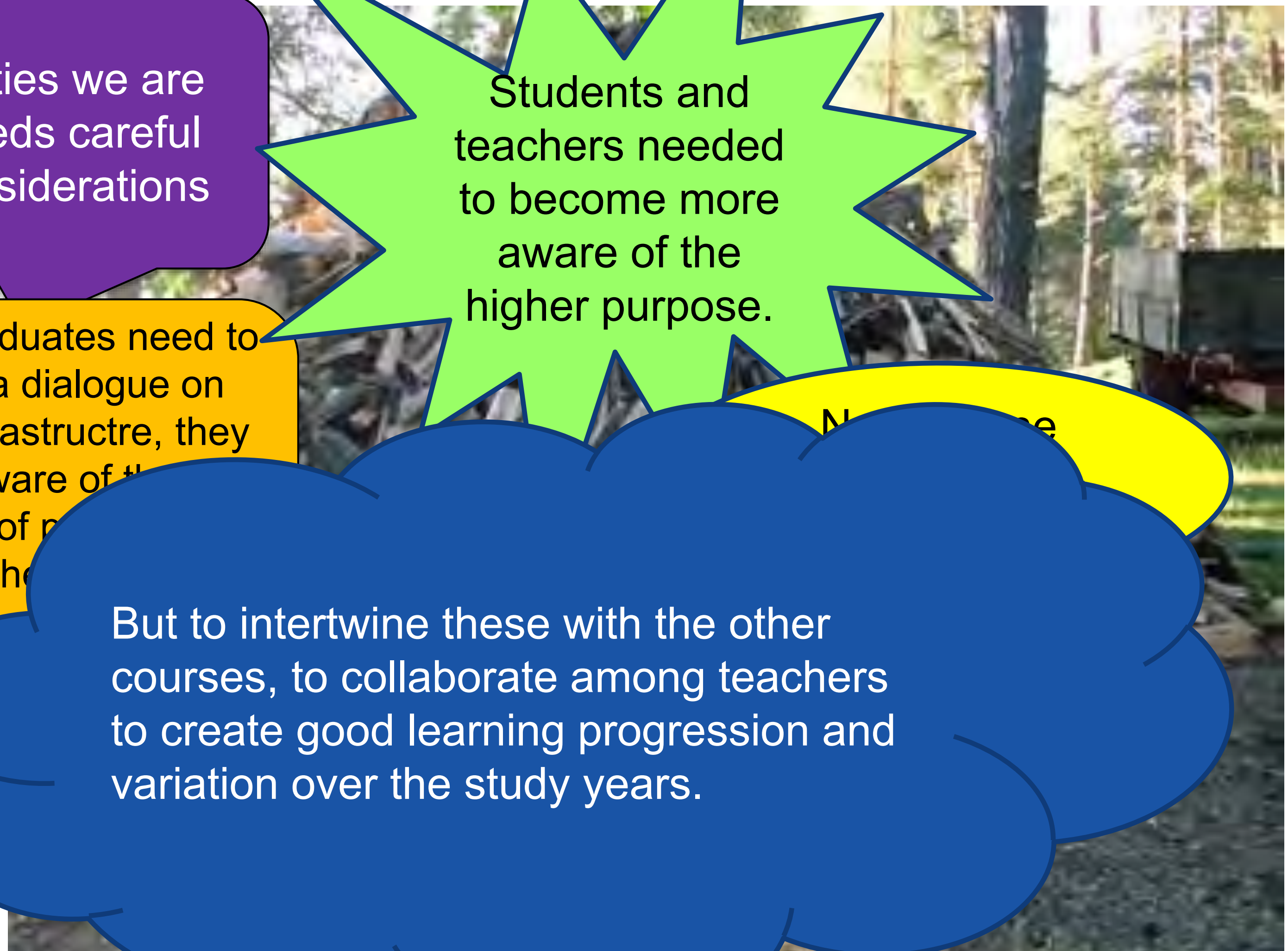
Organization / Institutional development

Vice rector for Sustainable Development
Sustainability Office
Sustainability Labled Courses
Target resources

Student development

Collaboration with "Sustainability Student Organization"

HE Professional Education Development: Like throwing wood logs on to its' pile?



But the complexities we are educating for needs careful and strategic considerations

Students and teachers needed to become more aware of the higher purpose.

The professional graduates need to discuss and have a dialogue on water, networks, infrastructre, they will need to be aware of th… context, the needs of p… environment,.And the… that they h…

But to intertwine these with the other courses, to collaborate among teachers to create good learning progression and variation over the study years.

Curriculum development (programs, courses, module)

Systematic collaboration among courses/faculty in the whole educational program

How well students reach the degree outcomes has become more interesting, instead of only looking at how well one isolated course achieves its goals

'create connections, sequences, timing and logical flow of assessment tasks across the whole program'

	Mechanics	development	
			analysis

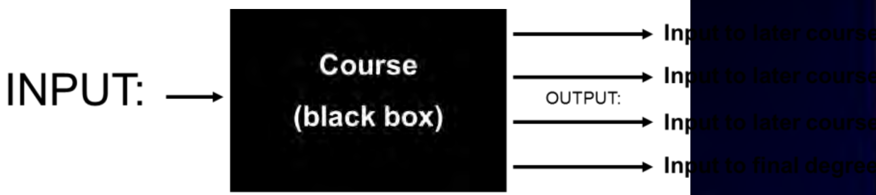
Cooperation among teachers, and not only on a departmental level, but across the study program's different courses, is seen as a key step to make this happen

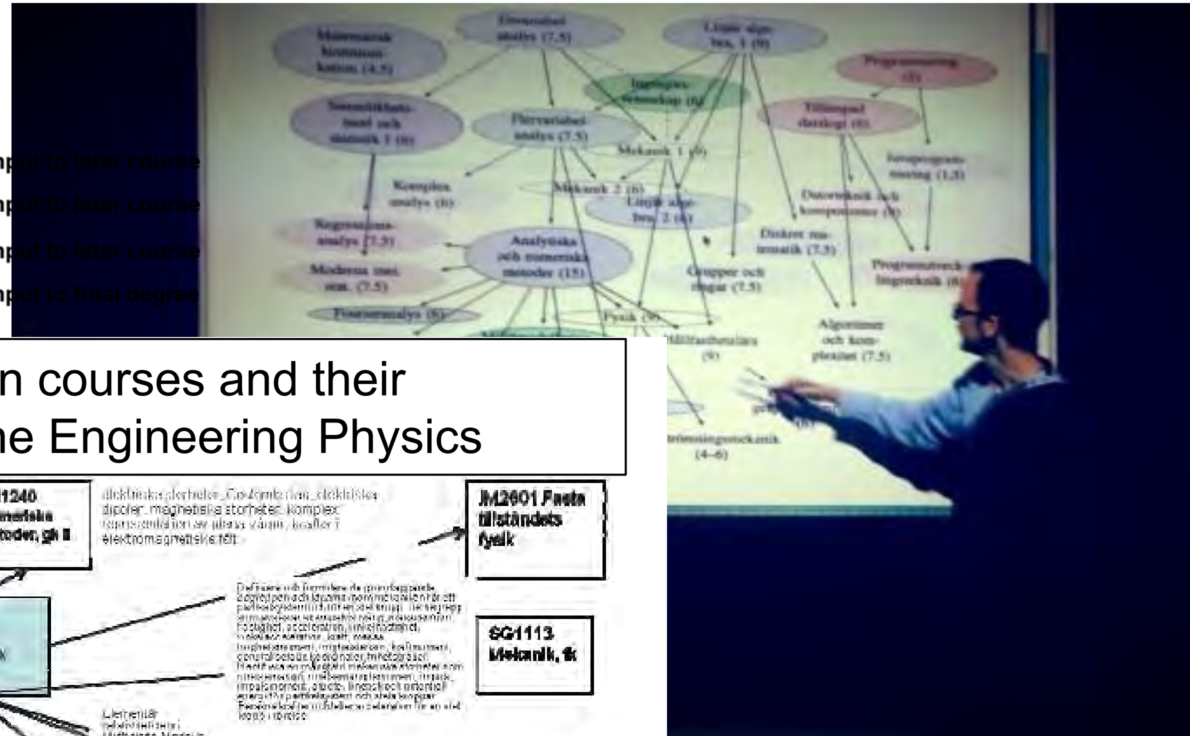
The whole is greater than the sum of its parts: a large-scale study of students' learning in response to different programme assessment patterns. Tansy Jessop, Yassein El Hakim & Graham Gibbs, Assessment & Evaluation in Higher Education Vol. 39 , Iss. 1,2014

Systematic work with program design and progression

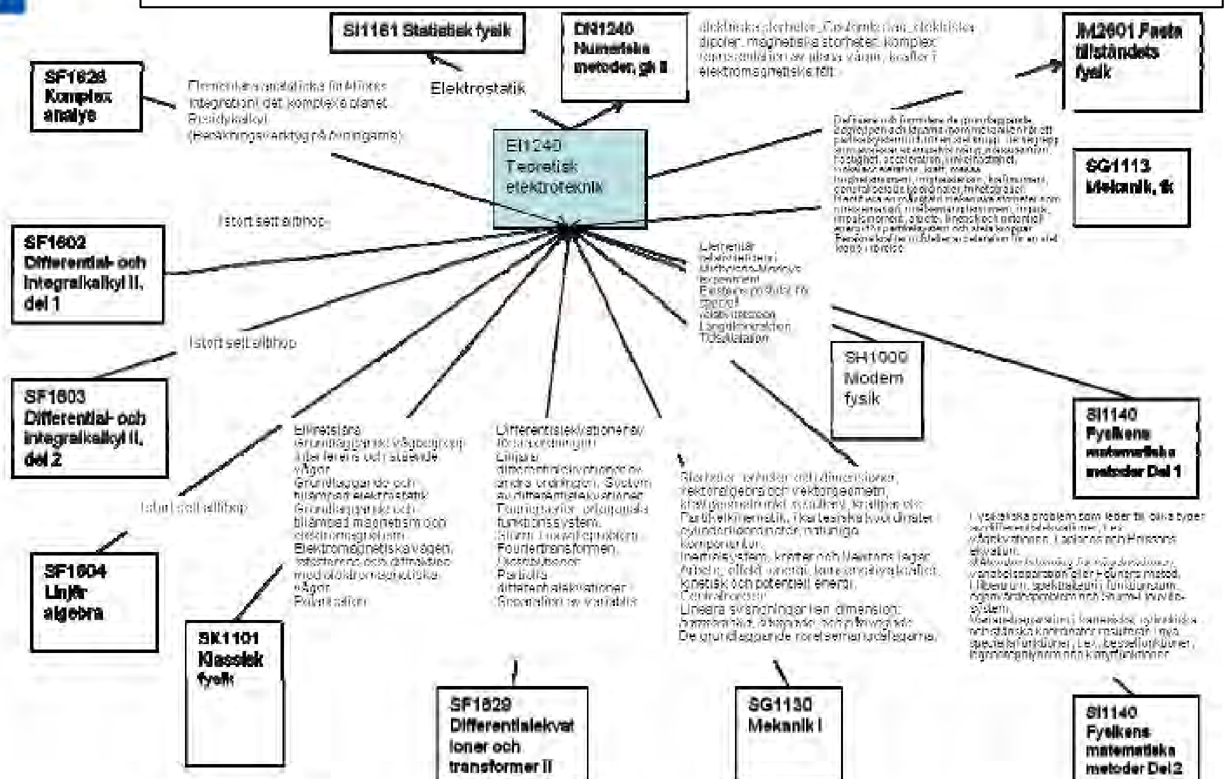
Development routes (schematic)				
Year 1	Introductory course	Physics	Mathematics I	
	Mechanics I	Mathematics II	Numerical Methods	
Year 2	Mechanics II	Solid Mechanics	Product development	
	Thermodynamics	Mathematics III	Fluid mechanics	Sound and Vibrations
Year 3	Control Theory	Electrical Eng.	Statistics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

Collaboration among teachers in program teams

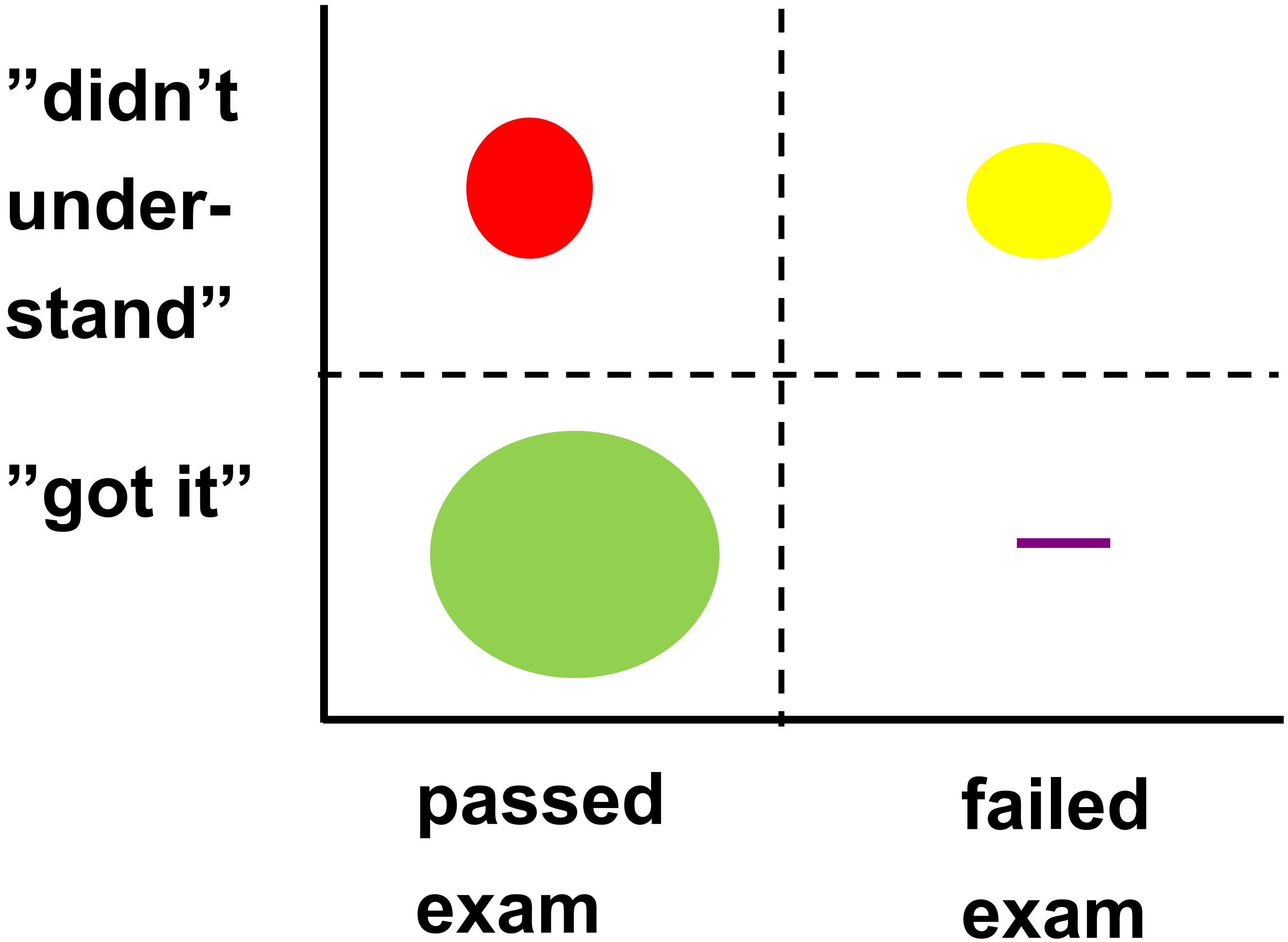




Connections between courses and their connections within the Engineering Physics



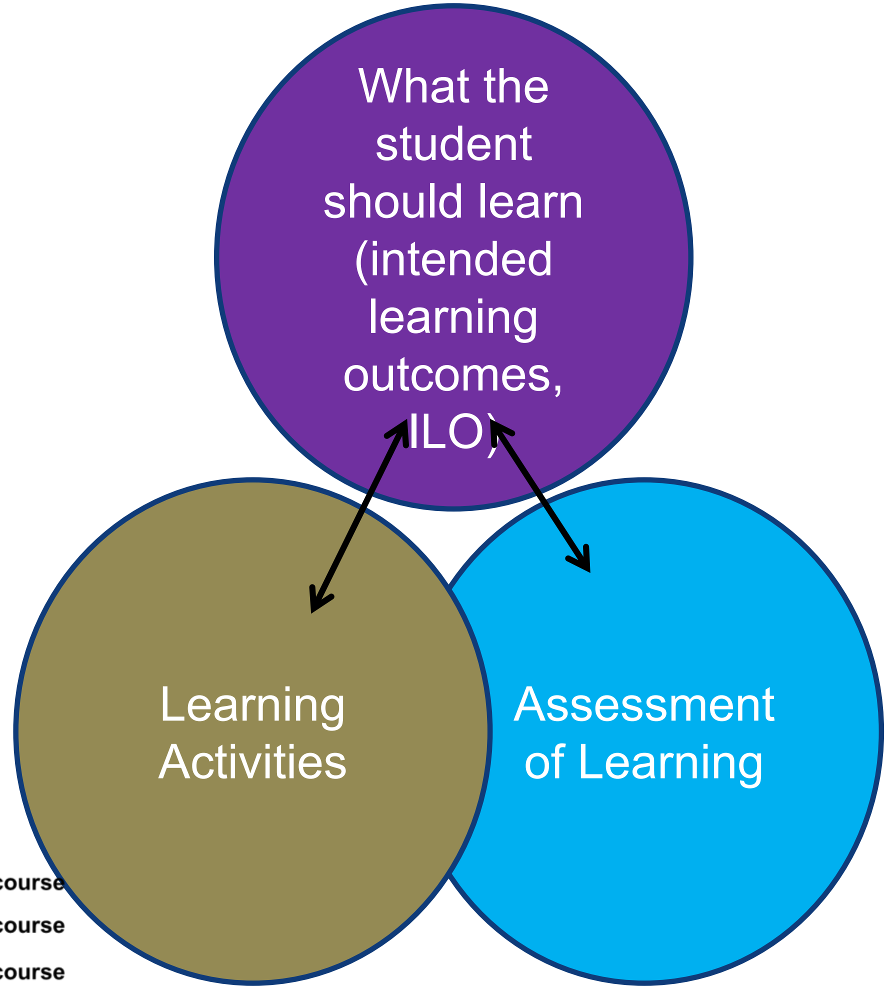
QUALITY OF STUDENT LEARNING

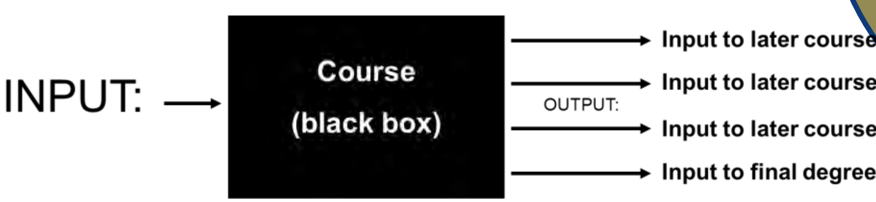


[Steve Hall, MIT]

The three fundamental questions in course design becomes quite useful

Faculty development





Three stages in learning

1. FIRST EXPOSURE
   first presented with new facts, concepts, vocabulary
2. PROCESS
   students analyze, solve problems, apply
3. RESPONSE
   getting feedback from peers, teachers and more

Distributed among available times:

- Class time
- Students’ study time
- Teacher’s own time

Increase class time hours spent on 2 and 3

-------AND TO UNDERSTAND ”LEARNING” BECOMES IMPORTANT-------

Education al change

Curriculum development (programs, courses, module)

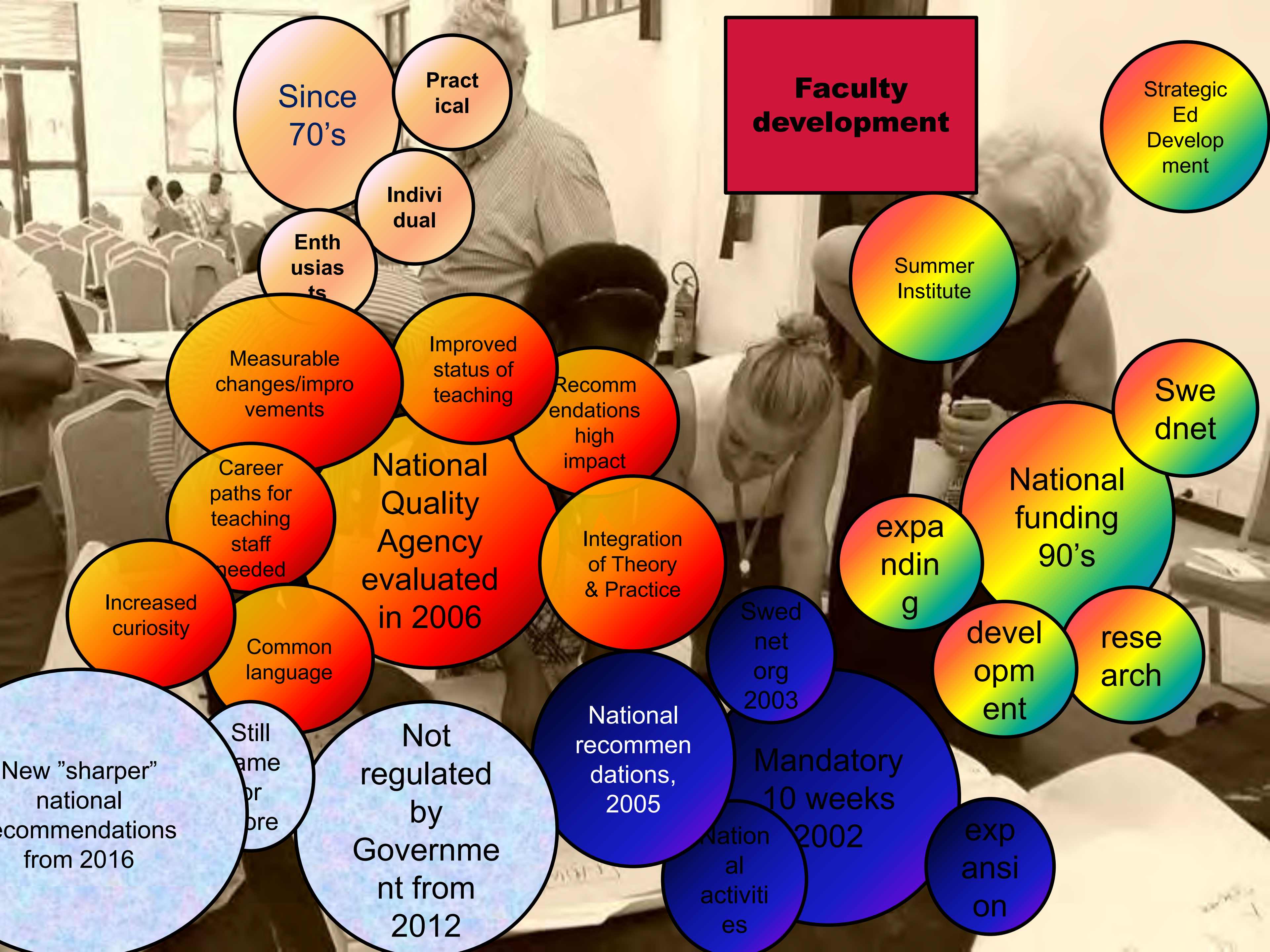
Learning outcomes, activities and assessment procedures

Linking, connection, progression

Quality assurance and enhancement procedures

Summary:

- Start with education / program level approach
- Single course development is also really good and can be a role model for the future!
- Talk to the responsible for education or the education program where you would like to contribute in the program development! Also ask higher management for support.
- What learning outcomes do you have for the program, and are they matched with society's input?
- Create discussion seminars on the program learning outcomes with faculty and students. Higher purpose awareness will be supported. You can also include stakeholders.
- Include discussions on levels, progression, variation
- Support teamwork and commitment in education development, from staff, teachers and students and leaders.
- From a program perspective, let all courses/teachers reply on how their courses match to the program outcomes
- Use the ”BLACKBOX” activity yearly on program conferences to keep the discussion going
- **RISK: Simplification**


Faculty development
Since 70's
Pract ical
Indivi dual
Enth usias
Strategic Ed Develop ment
Summer Institute
Measurable changes/impro vements
Improved status of teaching
Recomm endations high impact
National Quality Agency evaluated in 2006
Career paths for teaching staff
Integration of Theory & Practice
Increased curiosity
Common language
Swe dnet
National funding 90's
expa ndin g
devel opm ent
rese arch
Swed net org 2003
National recommen dations, 2005
Mandatory 10 weeks 2002
exp ansi on
New "sharper" national
from 2016
Still
Not regulated by Governme nt from 2012

Classroom → learning environment

Individuals → teams, departments; leadership

Small tactics, peripher →
complex, intregrated
central strategies

Reflections on the changing nature of educational development, Gibbs, 2013

Psychological → Sociological

Experiential, reflective, atheoretical, amateur
→ Conceptual, empirical, professional

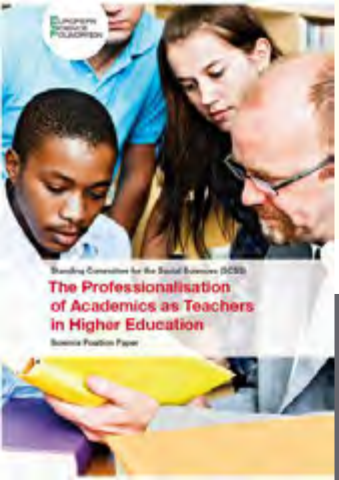
Gibbs, G. (2013). Reflections on the changing nature of educational development. *International Journal for Academic Development*, *18*(1), 4-14.

Typical educational development activities

Table 1. Typical educational development activities

1) **Teach** courses and workshops for teachers (incl. postgraduate students, newly appointed and more experienced academics)	5) **Research** student and professional learning and organisational development in higher education	9) **Contribute** during evaluation of teaching and quality assurance processes
2) **Consult** teachers and other individuals holding positions such as study directors, heads of departments, deans etc.	6) **Develop** new supportive teaching and learning structures, e.g. reward systems for good teachers	10) **Aid** in policy and strategy development, nationally and in institutions and departments
3) **Participate** in curriculum development processes	7) **Arrange** teaching and learning conferences	11) **Support** students' enculturation and development of study strategies
4) **Administer** teaching and learning funds	8) **Assess** pedagogical merits during hiring of new teaching staff and/or promotion	12) **Secure** personal professional development through scholarship, research and professional networks

Sources: Clegg, 2009; Gosling, 2006; MacDonald, 2009; Sorcinelli et al., 2006.



Swedish National Recommendations. 10 weeks: Faculty / HE Teachers training:

Sveriges universitets- och högskoleförbund
The Association of Swedish Higher Education
En arena för samverkan

The participant shall demonstrate the ability to

- discuss and problematize student learning in the participant's own subject area, on the basis of research in educational sciences and/or subject didactics of relevance for teaching in HE

- independently and jointly with others, plan, implement and evaluate teaching and assessment in higher education with a scientific, scholarly or artistic basis and within their own area of knowledge

- make use of, and assist in the development of, physical and digital learning environments to promote learning for groups and for individuals

- interact with students in an inclusive manner and demonstrate knowledge of rules and regulations regarding students with disabilities and of available student support

- apply relevant national and local rules and regulations, and to discuss society's objectives for HE and the academic teaching role in terms of the participant's own practice and students' active participation in HE

- on their professional approach to academic teaching and their relationship with the students, and also towards the fundamental values of higher education, such as democracy, internationalization, gender equality, equal opportunities and sustainability

- collect, analyze and communicate their own and others' experiences of teaching and learning practices, and relevant outcomes of research, as a basis for the development of educational practice and of the academic profession.

ADVISORY BOARD FOR FACULTY DEVELOPMENT

An advisory board that with good competence and legitimacy will provide with advice to the education that KTH is giving in the field of Teaching and Learning. The courses are firstly given to teachers (lecturers, associate professors, professors etc), researchers and PhD students. Also external course participants are taking the courses, from other universities in Sweden or collaborating institutions from other parts of the world.

- Strive to follow the recommendations (REK 2016:1)
- Strive to have a profile that befriends a quality driven development of present and future educations and learning environments at KTH

Namn	Funktion	Tillhörighet
Anna-Karin Högfeldt	Program Director	ECE
Margareta Bergman	Director of Studies	ECE
Fredrik Lundell	Manager, HERD.	ECE/ SCI
Anders Forsgren	Vice Dean, School of Science	SCI
Hans Havtun	Associate Professor	ITM
Jan Scheffel	KTH Education Committee, (UU)	EES
Josefin Wangel Weithz	Associate professor	ABE
Mona Fjellström	External expert advisor.	Umeå univ.
Per Berglund	Vice rector	UF
Emma Riese	PhD student.	THS
Elisabet Lövqvist	Student representant.	THS
Viggo Kann	HP-lärare och PU	CSC
Marie Magnell	Course responsible, LH231V (stora grundkursen)	ECE
Maria Weurlander	Course responsible, LH207V	ECE

(https://intra.kth.se/polopoly_fs/1.696451!/Appointments%20procedure%20for%20teachers%20at%20the%20Royal%20Institute%20of%20Technology.pdf)

Courses without extra prerequisites

PhD course: FLH3000 Basic communication and teaching, 3hp

LH231V Teaching and learning in higher education, 7,5 hp

LH216V Develop the Learning by Using Grading Criteria, 1,5 hp

LH207V Research Supervision, 3 hp

Course for International Visitors

Courses with 3hp as prerequisites

Courses with 7,5 (LH231V or corr) prerequisites

LH222V Ämnesperspektiv, 1,5hp

LH219V Exjobb: Handledning & Examination, 3 hp

LH228V Collaborative Online learning, 3 hp

LH215V Learning for Sustainable Development, 4,5 hp

LH221V Examinatorskap för kurser på KTH, 1,5hp

LH217V Leading Educational Development, 3 hp

LH220V Project in Educational Science, 4,5 hp

Specific continuation course

LH229V Online & Blended Project course, 1,5 hp

Upcoming

Equality in Teaching and Learning

Art Technology and design teachers

Challenge Driven Education

”mandatory”

Educational change

Faculty development

Knowledge

Skills and Competence

Values

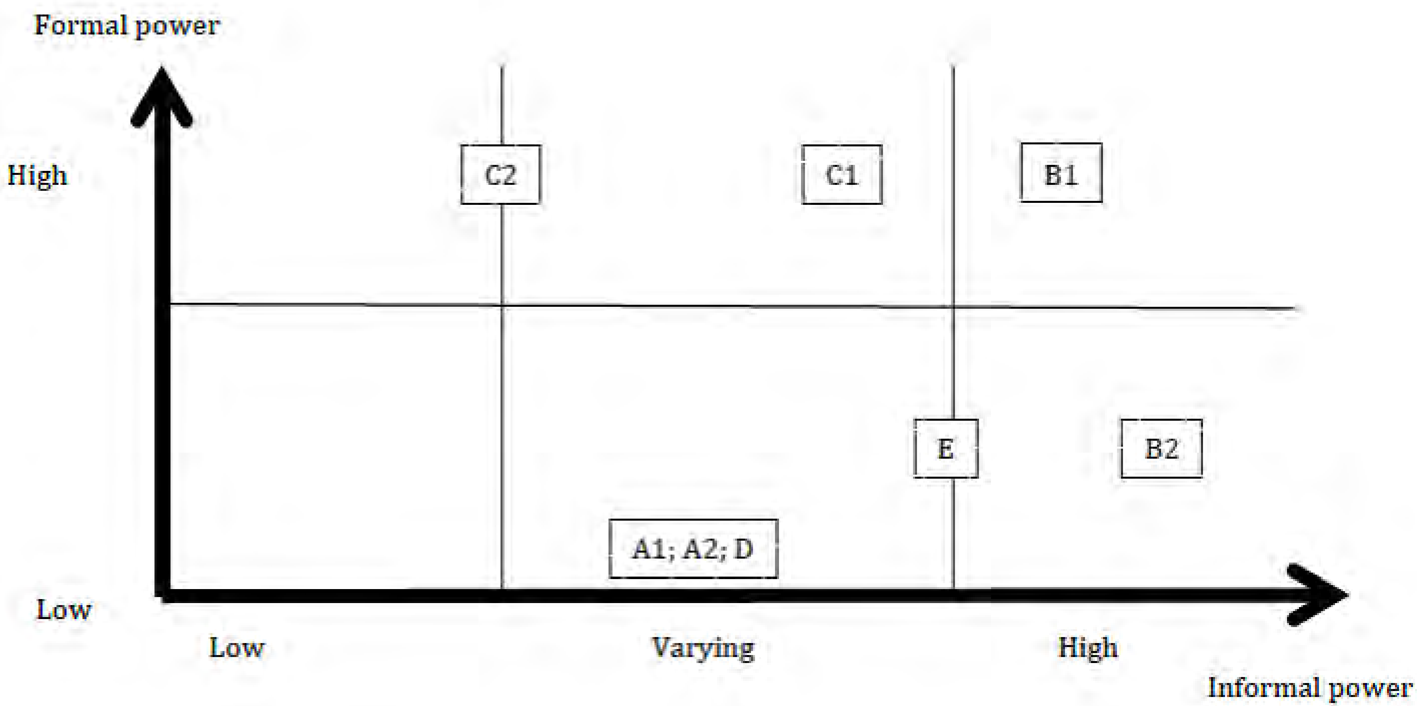
- Professional program perspective
- Intrinsic motivation
- Start small
- Logical order
- Supporting the development of faculty as team players with a shared goal
- RISK: Academic drift

KTH VETENSKAP OCH KONST

Organization / Institutional development

- Some of the teachers that we collaborated with on curriculum and faculty development 5-10 years back are now part of the management in various levels at the institution.
- If the recognition of teaching in higher education is to be improved, so must be the ways in which we give it value
- Organizational development could be argued to refer to having a university that supports the visions of the educational change in its decisions, plannings, policy making, room plannings, learning management systems, meeting forms, department borders, stakeholder interventions etc
- **Risk: that too much emphasis is put on giving some roles lots of power**

Leading the teacher team – balancing between formal and informal power in program leadership, Högfeldt et al (2017), Tertiary Education and Management



Rewarding Teaching I: Finding the key agents

KTH's Pedagogical Prize 2016
- selected by KTH staff.

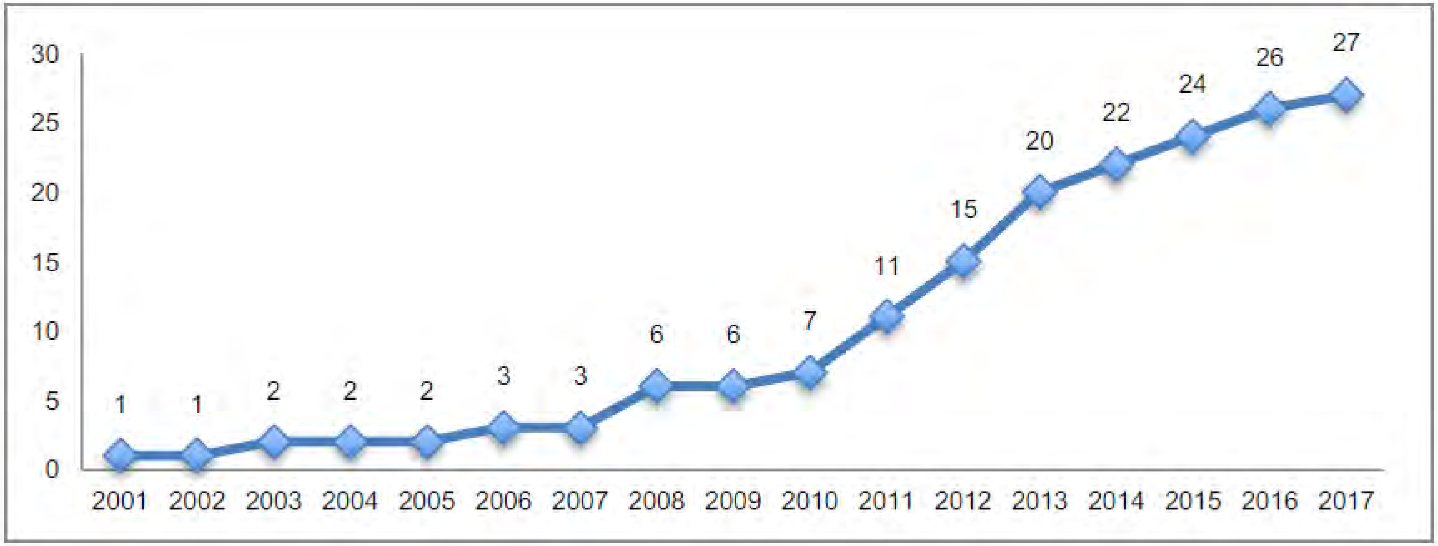
TEACHER OF THE YEAR 2016
- selected by students.

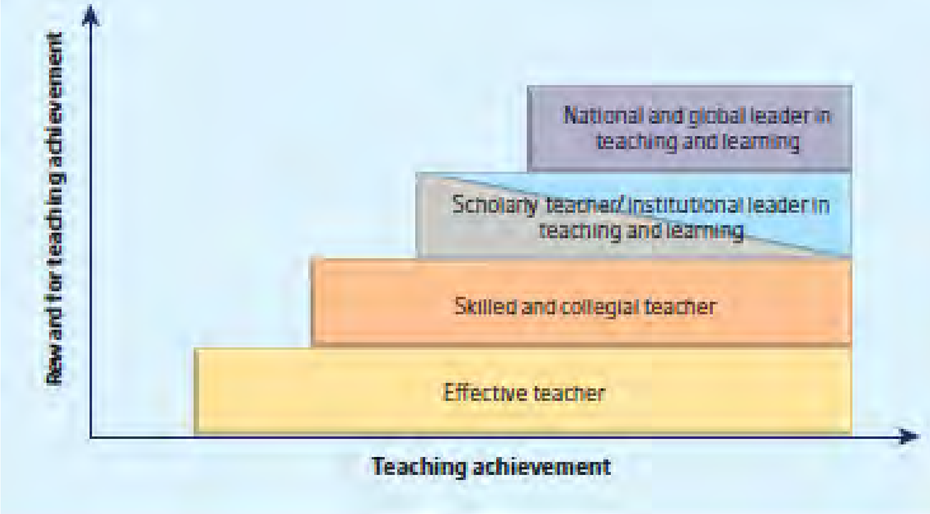
Best practice awards should not be underestimated

Organization / Institutional development

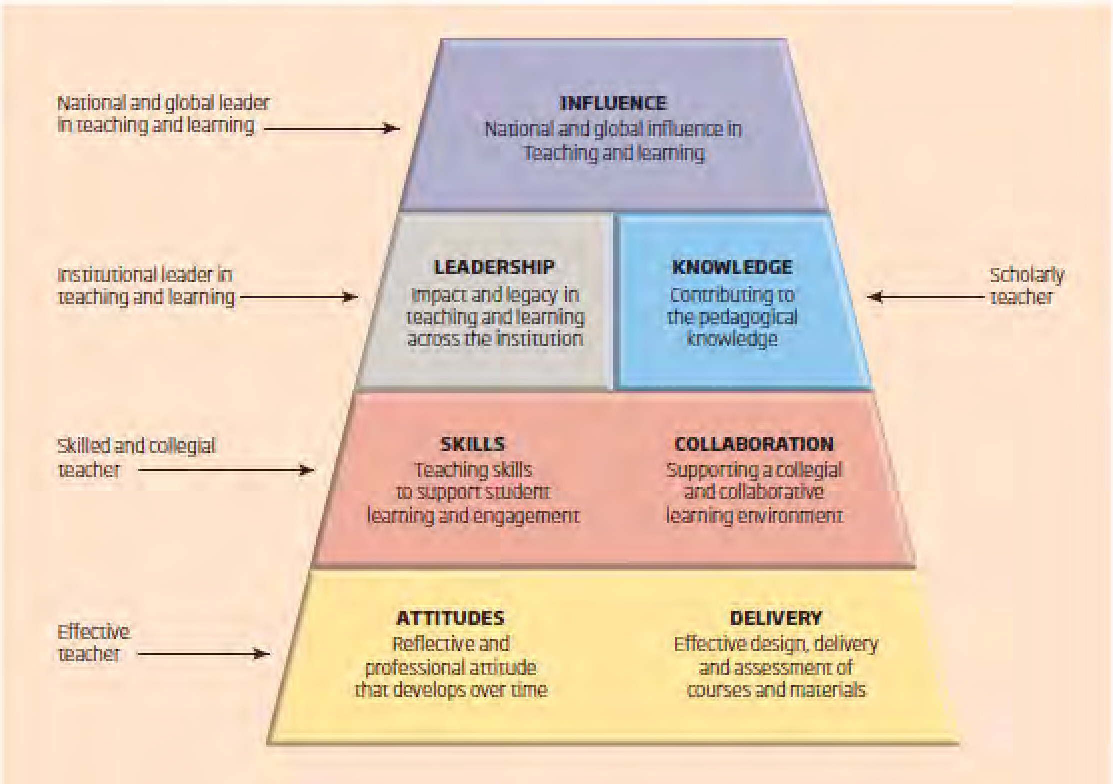
Rewarding Teaching II: Finding ways to evaluate teaching achievement systematically and broadly

- 49% of Swedish HE has implemented pedagogical career pathways for faculty
- Pedagogical portfolios are used at 70% Swedish HE institiutions
- More than 500 teachers in Swedish Higher Education have been promoted in a Swedish pedagogical career model




National and global leader in teaching and learning
Scholarly teacher/ institutional leader in teaching and learning
Skilled and collegial teacher
Effective teacher
Reward for teaching achievement
Teaching achievement


ROYAL ACADEMY OF ENGINEERING
Does teaching advance your academic career?


National and global leader in teaching and learning
INFLUENCE
National and global influence in Teaching and learning
Institutional leader in teaching and learning
LEADERSHIP
Impact and legacy in teaching and learning across the institution
KNOWLEDGE
Contributing to the pedagogical knowledge
Scholarly teacher
Skilled and collegial teacher
SKILLS
Teaching skills to support student learning and engagement
COLLABORATION
Supporting a collegial and collaborative learning environment
Effective teacher
ATTITUDES
Reflective and professional attitude that develops over time
DELIVERY
Effective design, delivery and assessment of courses and materials


Student
development

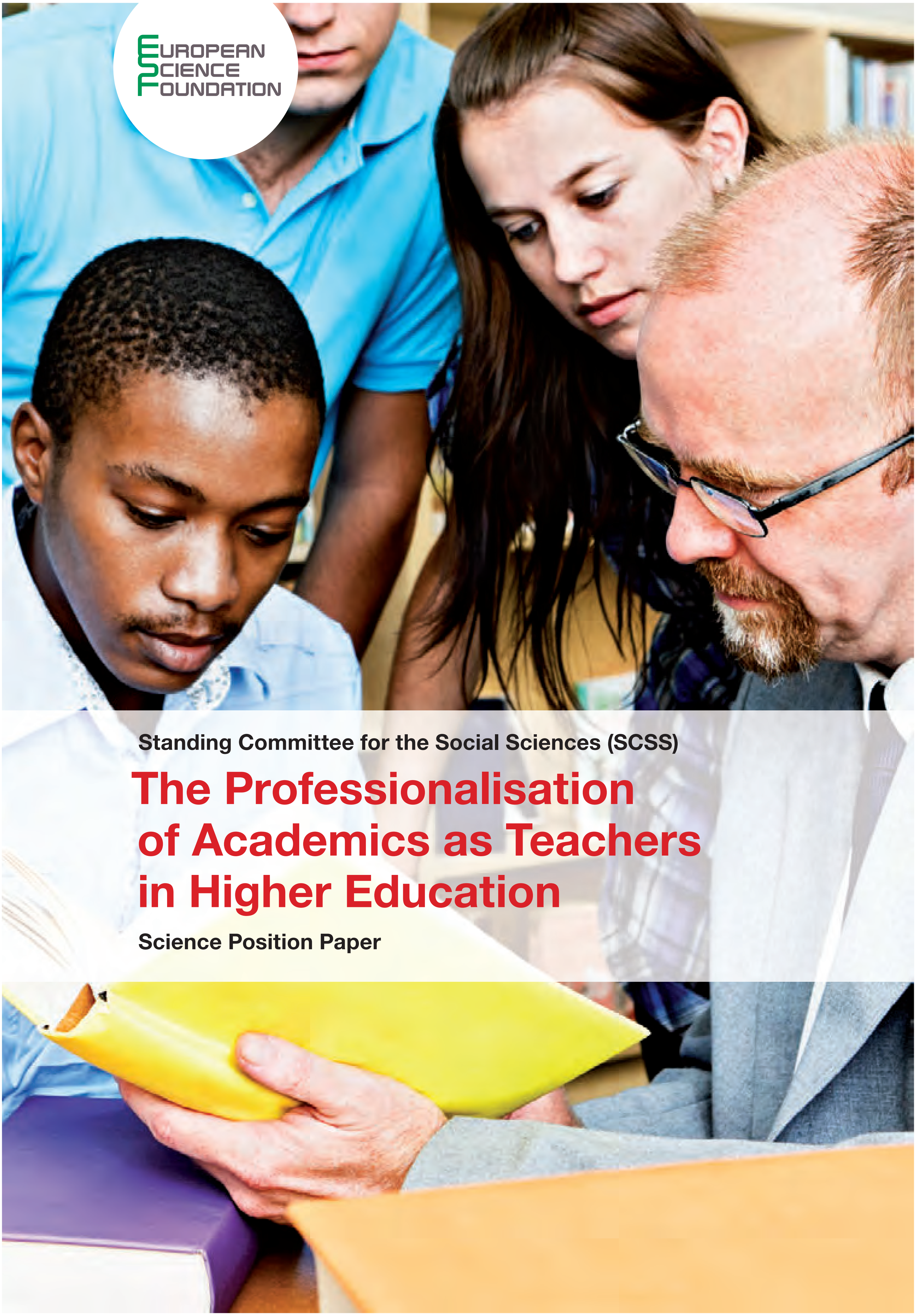
KTH ROYAL INSTITUTE
OF TECHNOLOGY

STRATEGIES FOR CHANGE AT YOUR INSTITUTION

Curriculum, Faculty, Organization and Students With a Shared Perspective – Desirable and Possible?

Presentations from each country

European Science Foundation



Standing Committee for the Social Sciences (SCSS)

The Professionalisation of Academics as Teachers in Higher Education

Science Position Paper

European Science Foundation (ESF)

The European Science Foundation (ESF) is an independent, non-governmental organisation, the members of which are 72 national funding agencies, research performing agencies and academies from 30 countries.
The strength of ESF lies in its influential membership and in its ability to bring together the different domains of European science in order to meet the challenges of the future.
Since its establishment in 1974, ESF, which has its headquarters in Strasbourg with offices in Brussels and Ostend, has assembled a host of organisations that span all disciplines of science, to create a common platform for cross-border cooperation in Europe.
ESF is dedicated to promoting collaboration in scientific research and in funding of research and science policy across Europe. Through its activities and instruments, ESF has made major contributions to science in a global context. ESF covers the following scientific domains:

- Humanities
- Life, Earth and Environmental Sciences
- Medical Sciences
- Physical and Engineering Sciences
- Social Sciences
- Marine Sciences
- Materials Science and Engineering
- Nuclear Physics
- Polar Sciences
- Radio Astronomy
- Space Sciences

www.esf.org

Science Position Paper

The objective of ESF Science Position Papers is to provide evidence-based foresight and advice on science, research infrastructure and science policy issues of European significance to underpin decisions on strategic directions and priorities. Special attention is paid to promoting Europe's ability to open up new research areas. Published under the responsibility of one or more ESF Standing Committees, they represent a considered opinion of the community represented by the Committee(s) involved.

www.esf.org/social

Authors

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with comments from Mieke Clement and Herman Buelens

This Science Position Paper has been prepared under the responsibility of the Standing Committee for the Social Sciences (SCSS):

Chair: Professor Sir Roderick Floud

Head of Humanities and Social Sciences Unit: Dr Nina Kancewicz-Hoffman

Editorial support: Mr Étienne Franchineau, Junior Science Officer

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Foreword

Investments in research and innovation are to a considerable extent moderated by the level and quality of higher education. Higher education is an important aspect of the 'absorptive capacity' of societies, the degree to which new knowledge is accessed, understood and used, and a crucial means of realising the ambition of making Europe more innovative. As one of the main 'outlets' for research, not just for social science but for science in general, higher education is one of the most important routes along which research has an impact on society, knowledge flowing via the heads of people into applications in daily life. State-of-the-art insights on teaching scientists how to teach, thus leveraging the knowledge embedded in their research, can be expected to increase the return on investment in science.

In 2009, the Standing Committee for the Social Sciences (SCSS) underlined in its position paper the importance of education as one of the Vital Questions and called for "adequate funding to train and develop the next generations of social scientists who will teach and aid the learning of one-third of Europe's students"[1]. In order to teach the next generation of researchers most effectively, the teaching skills of scientists are a crucial variable, to look at, study and improve. Obviously this is not only of interest to the social sciences but an issue of basic importance to all domains of science.

This position paper aims at presenting the state-of-the-art in the field and communicating the research issues that are still open. The overall objective is to increase the visibility of the growing research on improving teaching abilities of scientists through teacher development programmes, in order to increase application of this research and give input for the direction of further research in this area. Furthermore, it should help to increase the awareness of the importance of teacher training and of the quality of teaching in general.

Professor Sir Roderick Floud
SCSS Chair

1. Cf. SCSS Science Position Paper *Vital Questions, The Contribution of European Social Science, p.59*

Executive Summary

This position paper is an outcome of the European Science Foundation's Exploratory Workshop 'The Impact of Training for Teachers in Higher Education' held 18–20 March 2010 in Bratislava with the participation of 20 international academics engaged in both teacher training and researching teaching and learning in higher education. One of the conclusions of the workshop was that directing attention to teaching in higher education is critical for the future of European higher education. Accordingly, this paper calls the attention of policy makers in Europe to the pressing need to improve the quality of teaching in higher education and makes recommendations at the European, national and institutional levels to achieve this.

While effective teaching is vital for student learning in higher education, academics in Europe are not as prepared for their teaching careers as they are for their research. Recent changes in higher education make the development of academics' teaching skills a priority. National and international competition for students forces higher education institutions to market themselves to all potential students. Consequently, these institutions attract students with different levels of knowledge and skills. In some countries, as a result of increasing tuition fees, students demand better educational experiences. New technologies and a move towards online learning make it imperative that academics understand how to best facilitate learning in the digital environment.

Wider societal changes are also taking place in Europe. States are trying to transform their economies into knowledge economies, requiring that research be shared with society. Through teaching, higher education plays an important role in disseminating and promoting the use of research. Social and cultural changes accompany these economic changes: deepening democracy in Europe calls for citizens who are able to think critically and possess other skills and virtues, including, for example, empathy for different cultures. This cultural change also relies upon higher education.

The integration and regionalisation of European higher education demands that student learning experiences are of equally high quality across Europe. The Bologna process, which now recognises the need for improved classroom teaching, aims to increase student mobility. Mobility will only bring desired outcomes if students can expect attractive and competitive education at home and abroad. European efforts at quality assurance call for qualified and competent teaching staff so that the quality of education is enhanced and comparable across the region.

To help all students to learn in and for this changing environment, academics as university teachers need a better understanding of teaching and learning issues as well as to advance their pedagogic competences. Many current methods, such as widespread lecturing to students, relegate students to passivity, tend to focus narrowly on subject knowledge, and, thus, are inadequate. Instead, effective teaching needs to put student learning at the centre of the teaching process.

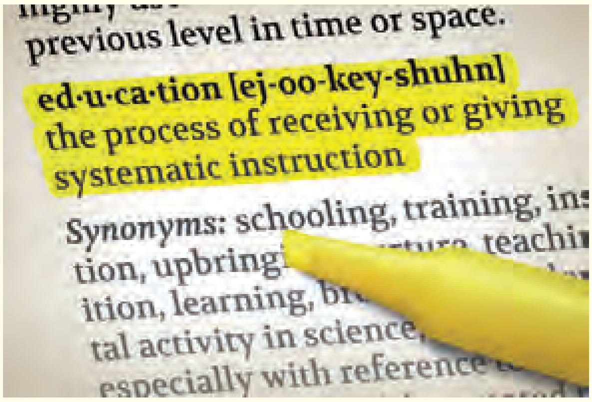
A number of European countries such as the United Kingdom, Ireland, Nordic and the Low Countries have already recognised the importance of classroom teaching for quality education. They have established teacher development programmes for academics and doctoral students, and professional associations to advance teaching and learning in higher education. Similar initiatives are taking place globally, with notable progress in the United States, Australia and Canada.

Contrary to these emerging global trends, in much of Europe, academics continue to rely on their own student experience when teaching. This reinforces subject- and teacher-centred approaches that do not stimulate desired high-quality learning experiences or the kinds of outcomes required by the new European social and economic context.

In order to professionalise academics in Europe as higher education teachers, we recommend that universities that strive for quality education offer educational development opportunities for their teachers. Excellent teachers are made, not born; they become excellent through investment in their teaching abilities. Leaving teachers to learn from trial and error is a waste of time, effort and university resources. Therefore, staff involved in teaching and supporting student learning should be qualified, supported and adequately resourced for that role.

The benefits from educational development programmes far exceed associated costs. The costs are usually relatively low, consisting mainly of staffing expenses for a programme coordinator (director) and several trainers (educational developers) and, possibly, also of a small grants fund for teaching enhancement. Well-designed educational development programmes lead to increased satisfaction of teachers and changes in attitudes, behaviours and teaching practice, as well as improved student ratings of instructors' teaching. Ultimately, such programmes aim to improve the quality of student learning and help to produce competent graduates.

To achieve this, we recommend harmonised action at the European, national, and institutional levels that elevates the importance of effective teaching in higher education. We suggest that policy makers also support existing initiatives. An approach that responds to European imperatives and targets individual, departmental, institutional and country-level initiatives without additional burdens on academic staff workload is the most desirable.



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When new teacher development opportunities are introduced, they should be voluntary, rather than compulsory. Early adopters will help ensure the long term success of the programme by serving as models that demonstrate the usefulness of student-centred approaches to teaching and by becoming champions of the approach.

Steps should be taken to:

- define professional standards for higher education teachers
- measure teaching effectiveness and provide constructive feedback for academics
- establish the institutional support base for educational development locally
- recognise teaching excellence in hiring and promotion decisions
- promote the idea of the 'teacher researcher'
- recognise research on teaching as research activity
- allocate meaningful funding for educational development
- establish a European forum within a currently existing institution that pools and shares resources and existing expertise on educational development across borders

Introduction

In many European countries, academics are prepared for their role as researchers, but not for their teaching duties. Despite growing evidence for the benefits of development programmes for teachers in higher education, teaching is still viewed as an activity that anyone can do. Thus, not surprisingly, only a few European countries have made substantial investment into enhancing the teaching abilities of their academic staff. In other words, the preparation of university teachers remains largely unsystematic and *ad hoc*. While formal degree programmes exist to develop and certify competence in research (Masters/PhD) and in some countries there is a clear expectation that academic staff are qualified to this level, the requirement to gain a formal qualification in teaching is not widespread.

Europe has established a European Higher Education Area (EHEA) with the purpose of creating comparable, compatible and coherent systems of higher education, increasing the employability of graduates, and enhancing the international competitiveness of European universities. Establishing professional standards for higher education teaching across Europe, the introduction of student-centred teaching, and the preparation of academics to fulfil these requirements are important steps to achieve these aims. So far, European policies have rarely affected the quality of teaching at the classroom level.

The Bologna process requires universities to assure the free movement of their students and academics between universities in other countries. However, successful implementation of this mobility policy requires that comparable high-quality educational experiences be offered throughout Europe. Offering attractive and competitive content of the curriculum and high-quality teaching that attracts students to study abroad are important means for ensuring that mobility will not be unidirectional or limited to certain countries.

Some European countries have already made significant progress in providing initial teacher training for postgraduate students and are increasingly offering opportunities for on-going professional development through accredited programmes in teaching and learning for academic staff. They have introduced postgraduate certificate, postgraduate diploma and Masters programmes in teaching and learning in higher education. In addition a growing number of universities are creating incentives for academics to perform highly in teaching through the introduction of institutional award schemes for teaching excellence.

Countries that are most advanced in terms of provision of educational development are those with a longer tradition of student-oriented policies. As a result of the widely diverse academic cultures within Europe, the level of attention to teacher development has been uneven. Interestingly, this training divide is not between East and West, but rather North and South (Pleschová and Simon 2008). While in the UK and in Ireland teacher development initiatives spread mainly as a result of customer-oriented and student-centred approaches to higher education, in Low and in Nordic countries they became products of increased attention to higher education as a driver for economic and societal development.

Importance of Educational Development for European Higher Education

The purpose of educational development (also called academic development, teacher development or teacher training) is to help create learning environments that enhance educational quality. In the absence of educational development, teachers in higher education tend to base their teaching on their own experience as students. In this way, old teaching methods that focus on the teachers' rather than the students' needs and on the subject matter rather than on the transformation of student knowledge perpetuate from generation to generation. In addition to the questionable effectiveness of such methods, lack of teacher preparation runs counter to political rhetoric, as well as current trends in and expectations of higher education.

Some European policy initiatives have already recognised the need to enhance the quality of teaching.

- The Bologna process has embraced student-centred teaching, quality assurance and quality improvement processes in higher education, student evaluation of teaching and diverse teaching and learning strategies.
- Similarly, the European Standards and Guidelines for Quality Assurance designate teachers as "the single most important learning resource available" to students and unambiguously call for professionalising higher education teaching. They recommend institutions monitor whether teaching staff are qualified and competent and assert that institutions "provide poor teachers with opportunities to improve their skills to an acceptable level and should have the means to remove them from their teaching duties if they continue to be demonstrably ineffective" (EAQAHE 2005, 17).
- Networks of European quality assurance agencies in higher education have been developed, and discipline-specific benchmark statements on expected learning outcomes have been formulated for all degrees.
- The EU Universities Multirank, initiated in 2009, aims partially at giving more importance to the quality of teaching.

In some European countries, national level policy initiatives have also appeared.

- In Ireland, the National Strategy for Higher Education to 2030, launched in 2011, reiterates a call for professional standards and for continuing professional development of teachers.
- The Higher Education Academy in the UK has developed a Professional Standards Framework (UKPSF) whose central purpose is to enhance the student learning experience, by improving the quality of their teaching and learning support.
- In Nordic countries, Belgium and the Netherlands, many universities have introduced educational development programmes as part of their strategy to enhance the quality of learning. At some of these universities, participation in such a programme is mandatory for getting an academic position. National conferences have been organised on improving the quality of education.

These trends are in harmony with initiatives in other parts of the world.

- In Australia, the Tertiary Education Quality and

Standards Agency contributes to analysis and evaluation of learning and teaching. This Agency registers and evaluates the performance of higher education providers against the new Higher Education Standards Framework.

- In universities in the USA, the DELTA programme by the Center for Integration of Research, Teaching and Learning has become increasingly popular. This programme promotes the development of future faculty members in the natural and social sciences, engineering, and mathematics who are committed to implementing and advancing effective teaching practices for diverse students as part of their professional careers.

In Europe, such declarations and other developments in higher education have reinforced each other, creating demands on teachers for which many are unprepared.

1. Student-centred teaching.

Putting students at the centre of the learning process creates new requirements for academics. First, it demands that they use teaching approaches that they may not be familiar with. Second, academics are now mandated to design learning outcomes and assessment, give and respond to feedback, embed an increasing range of skills into the curriculum, maximise the opportunities associated with classroom diversity and consider ethical issues. It is not feasible to expect academics to carry out these teaching roles effectively without appropriate support in the form of training and development programmes. All of these demands necessitate awareness and understanding of the theoretical underpinnings of teaching and student learning.

2. Knowledge economy and knowledge societies.

Because universities are traditionally engaged in both education and research (and, more recently, the validation of research), they are in a good position to help make research-based knowledge benefit society at large. Collaboration between active researchers and students is one of the best channels for new scholarly knowledge to be spread, contested and advanced in the professional community. Furthermore, learning from the most up-to-date scholarly knowledge and experience is a key ingredient in good teaching. Paradoxically, researchers are expected to introduce the most complex research findings to students who have much less disciplinary knowledge, but in many settings teachers are not offered adequate support to develop such pedagogic competence.

3. Changing conception of education.

Higher education has an important role in shaping our future society. There are calls for a greater emphasis on the holistic development of students, where all aspects of their growth as individuals in society are addressed (Quinlan, 2011). Not only is economic growth linked with the potential for universities to embed employability skills and a range of other generic competencies into the curriculum, but cultural change also relies upon higher education. Free, democratic societies require citizens and leaders who will think and contribute critically – intellectually, scientifically and morally – to their communities.

Higher education is where such citizens and leaders are formed and habits are developed for a lifetime of continued learning and support for scientific knowledge. That is, learning in higher education is more than just acquiring facts. It also includes skills development, helping students to make sense and meaning of the real world, and interpreting and re-interpreting what we know and how we know it. Achieving these aims inevitably necessitates changes to curriculum design and teaching methods, including increased attention to the development of 'soft' or non-disciplinary skills. Again, academics need help if they are to become leaders of this change.

4. Increasingly diverse student body.

As a result of the free movement of people and the existence of student exchange programmes, European higher education institutions are attracting an increasingly diverse student body. This includes higher numbers of international students, mature students, educationally disadvantaged students and students with a disability. These students come with varying degrees of prior knowledge, skills and preparation for higher education. Catering for this evolving student body

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requires a greater understanding from teaching staff about the range of approaches to learning. Growing international and inter-institutional competition for students forces institutions to market themselves to all potential students. Those institutions that can ensure the teaching competence of their staff will be at an advantage in the race for students.

5. **Diverse teaching staff.**
Mobility programmes, together with policies at individual universities that aim to attract the best academics, result in a diverse and international teacher body. Universities need to train teachers with backgrounds from other educational systems so they can make the best use of their competences in the particular local system. Teaching in a foreign language presents another challenge.

6. **The changing platform of education.**
Immense technological changes are taking place that should be exploited for the benefit of learning in higher education. There is abundant evidence that proper use of technology can enhance quality learning, particularly in part-time students and large enrolment courses, which are becoming prevalent in Europe. At the same time, using these technologies in teaching would also ensure that students are familiarised with technological innovations that they will need in the rest of their lives. Some institutions already provide for online learning and offer appropriate professional development to their teachers. However, many teachers still lack awareness about and skills for using IT effectively for teaching. Therefore, it is imperative that teachers understand how to facilitate learning in a digital environment. Educational developers that specialise in technology-enhanced learning, together with technology support staff, have proven to be valuable allies of teachers improving their courses.

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7. **Shrinking funding.**
The massification of higher education and the global economic crisis since 2007 have reduced levels of state funding for the university sector in both relative and absolute terms, increasing demands on universities to do more with less. Investment in preparing academics for their teaching duties is one way to make universities more efficient.

8. **Tuition fees.**
In institutions and states where students are paying higher tuition fees, they are demanding a better educational experience in return. At the level of individual courses, teachers need to be aware of the new types of learning outcomes and learning activities to satisfy student demands.

All these developments necessitate a practical response.

Defining Significant Learning and Good Teaching in Higher Education

The goal of professionalising academics as teachers is to enhance student learning. If teachers are to put students and their learning at the centre of teaching, they must also learn to inquire into their students' learning – to become aware of what students expect and care about, how they perceive the tasks and the learning environment, the approaches they take to learning, and how well they perform. Moreover, teaching calls for cooperation between individual teachers when formulating the programme aims, curriculum and assessment. In sum, teaching requires a scholarly approach, just as academics take a scholarly approach to their disciplinary research. Thus, academics need help to master basic educational principles and to make a conceptual and practical shift to more student-centred approaches to teaching. Moreover, they need support in adapting those principles and approaches in ways that suit their own context.

Teachers can put these principles into practice in a variety of ways. There are a host of active, engaged pedagogies that can be adapted to different disciplines and cultural contexts. For instance, some universities use service learning courses in which a community service project is combined with reading, writing and class discussions to allow students to meet academic goals through reflection on experiences in new settings.

Problem-based learning can be particularly motivating for students as it allows students to apply knowledge in real-world contexts. Such instruction begins with a problem that motivates students to study independently and in small groups to develop the knowledge necessary to analyse and solve the posed problem.

Lecturers who are faced with very large classes can solicit student questions before class (via instructional technologies) and design their lectures accordingly. They can divide their lecture into shorter segments, with interactive breaks in which students briefly explain and interpret key concepts.

Principles of good teaching

Good teaching is that which promotes student learning. From extensive bodies of evidence in the Anglo-American and Nordic contexts we know that students in higher education learn best when there is:

1. Frequent contact with academics in and out of class.
Students benefit from interaction with their teachers. It is motivating and promotes engagement with their studies.

2. Cooperation and collaboration with other students.
Learning is an essentially social activity. Collaboration among students allows them to articulate, test and challenge their assumptions, gives them access to classmates' knowledge and experience and a variety of perspectives on the topic and how to learn it.

3. Active involvement in thinking and learning.
Learning is an active, not a passive process. Learning happens when students read, talk, write, explain, make connections between ideas, try things out and observe the results, analyse, evaluate and organise their knowledge in meaningful ways. Good instruction engages students in processing and using new ideas rather than just listening to or watching their teachers. Teaching is simply the means of promoting student learning, not an end in itself.

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4. Recognition of and critical engagement with prior knowledge and experience.
Students come to higher education with prior knowledge and experience that can help or hinder new learning. If misconceptions and assumptions are identified and challenged, it facilitates deeper understanding. If existing knowledge becomes linked with new information, it can be more easily accessed, retrieved and applied later.

5. Time on task in goal-directed practice.
Students need to put time and energy into their learning. They must practise key skills, attending to particular goals or criteria.

6. Timely, specific feedback that gives guidance about progress and how to improve.
Feedback on student performances (e.g. writing an essay, giving a presentation, answering a question, demonstrating a skill) is one of the most powerful methods of instruction. Feedback helps to clarify what good performance looks like, and provides information so that students can monitor their own performance and close the gap between the desired and actual performance.

7. A challenging, yet supportive, learning environment.
Students do best when teachers set and communicate high expectations for them. However, as they feel challenged, they also need emotional, social and intellectual support.

8. Relevance to students' goals and intrinsic interests.
Students are more motivated when they have some control over their learning and when they see its relevance to their own lives, goals and interests. Motivation also depends upon them expecting to succeed in the task and perceiving a supportive environment.

9. Encouragement to and practice in becoming independent in their learning.
Self-directed, independent learners are proficient at assessing a task and its requirements, planning their approach, evaluating their own knowledge base and (learning) needs, identifying and effectively using resources, applying and monitoring various strategies and, finally, assessing their own performance against internalised performance standards.

While academics can learn a variety of different teaching methods that embody key educational principles (see the side bar), they must also:

1. Learn how to use knowledge about their students' experiences and perspectives to design their courses and teaching.
2. Be clear about their expectations of students and what they want students to learn.
3. Prioritise the knowledge, skills, values and attitudes they focus on.
4. Align instructional activities and assessments with intended learning outcomes.
5. Adjust their teaching according to students' needs and progress.
6. Use student feedback and reflection to progressively improve their courses.
7. Collaborate with other academics in these activities. Teaching is a collective responsibility.

If teachers – and the universities in which they work – adopt a more student-centred view of teaching as encapsulated in this section, their students will learn more deeply, and they are more likely to be intellectually and morally transformed by their university experience. But the higher education sector needs to be willing to promote this kind of significant learning and help teachers learn how to achieve those aims. It must create environments in which student learning of this kind can take place and in which teachers are rewarded for engaging in such practices. It will not happen by itself.

Educational Development: helping academics and universities promote significant student learning

Many countries, including the USA, Australia, Canada, UK, Ireland, Nordic countries, The Netherlands and Belgium have well-established educational development practices. However, educational development is not evenly available to academics and universities across Europe. If all of Europe is to benefit from the transformative potential of higher education, investment must be made in educational development across Europe.

While it is academics who actually improve teaching, professional educational developers (EDs) play an important role as they help teachers to develop their pedagogic competences. EDs are organised in teaching and learning centres, but also as departments or in human resource units. This variation reflects the many strategies used: alliances with academic leaders result in top-down strategies, but EDs may also work bottom-up through teachers as individuals, in groups, and networks in departments and/or programmes. They support study directors, programme leaders, deans and vice chancellors/rectors/presidents (see Table 1) in their initiatives to improve quality of education.

Table 1. Typical educational development activities

1) **Teach** courses and workshops for teachers (incl. postgraduate students, newly appointed and more experienced academics)	5) **Research** student and professional learning and organisational development in higher education	9) **Contribute** during evaluation of teaching and quality assurance processes
2) **Consult** teachers and other individuals holding positions such as study directors, heads of departments, deans etc.	6) **Develop** new supportive teaching and learning structures, e.g. reward systems for good teachers	10) **Aid** in policy and strategy development, nationally and in institutions and departments
3) **Participate** in curriculum development processes	7) **Arrange** teaching and learning conferences	11) **Support** students' enculturation and development of study strategies
4) **Administer** teaching and learning funds	8) **Assess** pedagogical merits during hiring of new teaching staff and/or promotion	12) **Secure** personal professional development through scholarship, research and professional networks

Sources: Clegg, 2009; Gosling, 2006; MacDonald, 2009; Sorcinelli et al., 2006.

Effective Educational Development

Three decades of educational development work has shown how to best prepare academics to teach and how to best enhance teaching and learning in universities.

First, educational developers work with individual teachers to help them improve their teaching. Well-designed, sustained programmes of study – rather than short, one-off workshops – (Ramsden, 1994) have been shown to impact teachers' thinking and conceptions of teaching and learning (Postareff, Lindblom-Ylänne and Nevgi, 2007; Stes, Coertjens and Van Petegem, 2010) and, in turn, their teaching practices (Stes, Clement and Van Petegem, 2007). Programmes which integrate ideas about how students learn and how assessment and teaching affect learning, lead to more effective teaching than programmes based only on improving teaching skills. In these effective programmes, classroom strategies and theory are closely intertwined. The most successful programmes are related to participants' own needs, as well as offering opportunities for interaction with colleagues.

Secondly, learning and change require supportive contexts. Thus, effective educational development also involves creating cultures in which academics are encouraged to experiment with student-centred curricula and teaching methods. There are various levers for culture change, including incentives such as grants, formal/informal recognition and reward structures, peer learning and exchange forums within departments, disciplines and universities. EDs work to build a shared language and understanding about student learning. Because of their varied disciplinary background, EDs habitually take the role of brokers, carrying information and innovations in teaching across disciplinary boundaries.

Thirdly, in many countries universities have introduced student evaluation of teaching as a way of ensuring student input into teaching enhancement. While this is a laudable first step, collecting and collating student reactions to teaching is not sufficient. Information about academics' teaching should be collected from other sources and, in order to create educational change, teachers need access to and the opportunity to discuss evaluation results to consider how to address weaknesses and build on strengths. Educational developers can help with this interpretation and action planning.

And fourthly, successful educational development programmes are regularly evaluated for their impact and restructured accordingly.

Training for educational developers

Institutions that introduce an educational development programme must consider whom to engage in this work. Professionals with qualifications in pedagogy for primary and secondary education may not be the right candidates for these posts, as working with students and staff in higher education requires different approaches and methods. In the past, educational developers typically started as academics in their particular discipline and became enthusiastic about teaching. They learnt the essence of educational development through running workshops and other activities for their colleagues. Today, a number of programmes offer qualifications for the profession of educational development. In some countries, universities offer Master's degrees in Higher Education either as a full-time or as a part-time programmes.

Professional associations also further the work and training of educational developers. The Staff and Educational Development Association (SEDA) in the UK regularly organises three-day summer schools for new educational developers. SEDA and another British institution, the Higher Education Academy (HEA), prepare training programmes and offer professional recognition for teaching. The HEA UK offers university managers access to consultants, assists institutions with data collection necessary to evaluate teaching and educational development programmes, and fosters disciplinary networking.

Continuing education opportunities also exist as exemplified by the Swedish Strategic Educational Development programme that brought together educational developers from across Sweden in 2004/2005 and 2005/2006 and offered a project-based environment for participants to work on problems relating to their professions. Conferences such as those of SEDA, the International Consortium for Educational Development (ICED), the HEA UK, International Society for Scholarship of Teaching and Learning (ISSOTL), or the National Academy for Integration of Research, Teaching and Learning (NAIRTL, Ireland) workshops, and online courses offer further possibilities for academic developers to enhance their knowledge and skills.

Some opportunities are available in Central Eastern Europe, too, such as the four-day workshop entitled Enhancing Teaching and Learning and Faculty Development at Universities in Europe offered annually by Central European University and its partner institutions.

Recommendations

In order to professionalise academics as teachers in higher education, we recommend elevating teaching and learning on the agenda of higher education policy-making. We propose concerted action at the European, national, and institutional levels that creates opportunities and incentives for academics to raise their interest in and improve their classroom teaching. This means that educational development should not be made compulsory in the short term or in the early phases of these efforts. Instead, teachers should be offered an opportunity and shown the associated benefits. We advocate a slower-paced, progressive introduction of educational development that first creates champions among the faculty and demonstrates the impact of student-centred teaching at the local level. Any action furthering good teaching should take into account the identity of academics as researchers. Thus programmes need to support rather than dictate participants' efforts to enhance their teaching and student learning. Our recommendations are to:

1. Define professional standards for higher education teachers.

The standards should allow for recognising and benchmarking teaching and learning support roles within higher education and articulate the professional knowledge base, for example, as was recently done in the UK.

2. Measure teaching effectiveness.

Building research evidence related to teaching, learning and educational development creates a base for improving existing practice. In the future, more systematic data collection and analysis is required. Some areas that need further exploration include the investigation of the temporal impact of educational development programmes on teachers' conceptions, teachers' behaviour, and student learning; how quality assurance practices influence classroom teaching; what types of interventions and programmes are the most effective when desiring a given impact on a particular group, such as PhD students; and how different educational systems and hiring practices influence change in teachers' attitudes and behaviour (Simon and Pleschová, 2012).

3. Establish educational development at the appropriate levels (institutional, regional, national), which includes the following:

- *Establish educational development programmes.* Education can only be enhanced if the quality of classroom teaching is improved. Excellence in teaching is a result of improving pedagogic knowledge and abilities. Simply learning by doing threatens to entrench traditional practices, which are no longer adequate in the changing context.
- *Create educational development units.* Through offering teacher development programmes, educational development units can systematically help teachers to enhance their pedagogic abilities. They can provide teachers with efficient and friendly feedback on teaching and promote sharing of results from research about student learning among teachers. This way, teachers gain insights into those aspects of their teaching that need to be improved. Educational development may be localised at the department, faculty or university level, yet regional, national and supranational training opportunities are also advisable, especially through disciplinary educational development.
- *Train educational developers.* When new educational development programmes and units are created, finding qualified staff is one of the key

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challenges. Here, cooperation with colleagues from institutions with established educational development practice is essential.

4. Strengthen the identity of academics as teachers around the concept of 'teacher-researchers'.

Although the emphasis may be on either teaching or research for academic staff, academics should be encouraged to engage in both, as there is a symbiotic relationship between them. As part of this,

- *Recognise teaching excellence in hiring and promotion decisions.* We can expect most academics to invest in teaching only if such investment is valued in the profession. To be hired or promoted, academics who teach should demonstrate qualification both as researchers and as teachers. The mutual recognition of acquired teaching qualifications and skills across states and higher education institutions is also desirable.
- *Recognise research on teaching and learning as research activity.* Researching teaching and learning issues involves similar methodological and research expertise to subject-based research. Therefore, it should be considered as a legitimate research activity.
- *Integrate educational development into the existing academic workload.* Participation in teacher development should be included among the responsibilities of the academic staff without creating any further workload. Otherwise teaching and research responsibilities could be antagonised and the efforts to improve education could fail.

5. Provide funding.

We advocate substantial long-term funding for teaching-related projects. We also recommend that funding opportunities be available at multiple levels (institutional, state, European). If no additional funding is available, then some of the existing research funding should be allocated for this purpose.

6. Establish a European forum.

In order to facilitate the implementation of these recommendations at the departmental, university, national and European level, we propose establishing a new forum. This forum should create incentives and harness already existing expertise while involving a greater number of countries and institutions in teaching-related issues. Such a European forum, focusing solely on the issues concerning European higher education and responding specifically to European contexts, does not exist currently.

An already existing organisation, such as the European University Association (EUA), could provide the necessary institutional and financial support for the forum.

Proposed responsibilities of the new European forum for higher education teacher development

• Stimulate discussion.
It should be a place where professors, educational developers and higher education managers could discuss issues related to classroom teaching and educational development. An annual "SoTL-Europe" conference, and regular workshops could be particularly useful to this end.

• Pool resources and provide expertise.
We propose that a European-level effort be based on matching existing expertise with local needs. To achieve this, maintaining a database on expertise relating to educational development would be essential. Additionally, the capacity to respond to local (national or institutional) needs by matching institutions and states with experts in the requested issues relating to teaching and learning is necessary.

• Utilise existing efforts and capacities.
This new forum would work with and through national institutions, teaching and learning organisations where they exist, and national and European disciplinary organisations.

• Facilitate cross-national mentoring programmes.
The forum should provide the capacity to match institutions or individuals for cross-national mentoring programmes.

• Administer and award funding for teaching projects.
Funding should be provided on multiple levels and for a selected number of varied projects. As part of this, the forum should:
- encourage teaching consortiums for semester or year-long exchange programmes for educational developers and teachers and for other joint teaching-related initiatives,
- stimulate individual efforts by providing small funds for teaching innovations and evidence-based educational development, in particular for teachers who have difficulty getting funding elsewhere,
- allocate funding to the regular evaluation of impact of educational development programmes and their redesign,
- promote projects based on the forum's expertise and capacities, such as mentoring projects.

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Annex

ESF Exploratory Workshop
'The Impact of Training for Teachers in Higher Education'
Bratislava (Slovak Republic), 18-20 March 2010

Programme

Day 1: **Thursday 18 March 2010**

The scope and impact of existing training programmes – an international survey:
Goals, content, participation and participants' motivation, subject-specific vs. interdisciplinary training, results and effects

14:00
Welcome address, purpose of workshop: G. Pleschová

14:15
Presentation of the European Science Foundation (ESF): B. Kiss, ESF Standing Committee for Social Sciences (SCSS)

Session 1:
Approaches to training in European Higher Education. National and international model
Purpose of the session: To find out
1) what type of teacher training currently exists internationally (especially in Europe), and to what extent is such training research-based or "evidence-driven"
2) what evidence exists for the effectiveness of such programmes
3) what methods might be used to establish or investigate programme effectiveness – e.g. their effects on teacher attitudes and teaching practices, on teacher effectiveness, and on student learning

Chair: J. Murphy
Record-keeper: J. Renc-Roe

14:30
The influence of courses in university pedagogy at the University of Helsinki on educators 'teaching and students' learning. 2001-2009 experience: A. Nevgi

14:50
Academic practice workshops at the European University Institute as a part of Max Weber Programme. Evidence from the praxis: A. Frijdal

15:10
The design and effectiveness of CEU (Central European University) approach to teacher training-two models of practice: J. Renc-Roe

15:30
From beginning teachers to educational leaders: Tensions and possibilities in educational development from a career stage perspective: K. Quinlan (Oxford University)

15:50
Break

16:10
'Fit-for-purpose': Designing and running an accredited CPD (Continuing Professional Development) route at University of Ulster to meet institutional and staff needs: S. Maguire

16:30
Two education development strategies: A Problem-based learning module and academic writers' retreats at University College Dublin: T. Barrett

16:50
The effects of different forms of educational courses on university teachers' teaching practice at the University of Tartu: M. Karm

17:10
Discussion resulting in a critical evaluation of the impact of existing programmes on participants' teaching and their students' learning

18:45
Dinner

Day 2: **Friday 19 March 2010**

Effectiveness of training:
Impact on curriculum, on teacher effectiveness, on student learning

Morning session:
Designing an effective teacher training programme
Purpose of the session: Determining what requirements should a teacher-training programmes live up to discussing systemic effects of pedagogic training

Chair: Ch. Knapper
Record-keeper: E. Simon

8:40
The proof of the pudding: to make teachers actually change something to improve their own teaching practice: P. Lauvas (University of Oslo)

9:00
The impact of the integration and internationalisation of HE systems on teaching and learning: E. Berndtson (University of Helsinki)

9:20
Eastern European Transformations in Academic Identity and Practice – the Internationalisation factor: J. Renc-Roe (Central European University)

9:40
Break

10:00
High quality learner-centred teaching, teamwork and aligned assessment. An opportunity for the students to become democratically engaged in learning:
D. Jacques (Oxford Brookes University)

10:20
Systemic effect of pedagogic training: T. Roxa (Lund University)

10:40
Discussion resulting in suggesting a model strategy for teacher development in HE

12:00
Lunch

Afternoon session: two parallel tracks

Track 1: Measuring the impact of teacher development. Critical appraisal of existing methods

Purpose of the track: Critical assessment of existing methods for measuring the effects of staff development (SWOT analysis)

Chair: K. Quinlan
Record-keeper: J. Renc-Roe

13:40
Incorporating research on learning into teacher training programmes: Ch. Knapper (Queen's University)

14:00
Accredited programmes in teaching and learning in higher education – some Irish perspectives on measuring impact: J. Murphy (University College Cork)

14:20
New lecturers' views of assessment: L. Norton (Hope University)

14:40
Quantitative and qualitative methods in examining the impact of teacher development: K. Triggwell (University of Sydney)

15:00
Break

15:20
Surveying self-efficacy of teachers using ATI questionnaire and interviews with educators:
A. Nevgi (University of Helsinki)

15:40
Discussion resulting in SWOT analysis of existing methods measuring the effects of educational development
Brainstorming about possible research projects

Track 2: Role of IT in stimulating teachers' engagement and efficiency of teaching

Purpose of the track: to answer following questions:

1) To what extent might training, teaching and learning reflect the increasing variety of technologies students use in their daily lives, from I-pods to mobile phones?
2) How do teachers react to contemporary requirements and/or new possibilities offered by the introduction of advanced technology into the classroom?
3) Are teachers sufficiently equipped with IT skills? How might the introduction of technologies stimulate or detract from teachers' engagement and confidence in increased efficiency of teaching?

Chair: Ch. Rabl
Record-keeper: V. Davies

14:00
Bridging the Gap: developing academic staff in Technology-enhanced Learning (TEL):
V. Davies (University of Ulster)

14:20
Using Social Media to Enhance Student Learning in Political Science: C. Goldsmith (De Montfort University Leicester)

14:40
Advantages and weaknesses of ITCs in teaching and learning: S. LaBranche (Institute of Political Science Grenoble)

15:00
Break

15:20
Media Zoo as a Catalyst for Institutional Change: Introducing Learning Technologies to Teaching Staff at the University of Leicester: S. Kear – via Adobe (University of Leicester) https://connect.le.ac.uk/mediazoo/

15:40
Discussion resulting in concluding how the introduction of IT can stimulate or detract from teachers' engagement and confidence in increased efficiency of teaching

17:00
Preparing draft proposal to be discussed next day (convenors)

19:00
Dinner

ESF Exploratory Workshop
'The Impact of Training for Teachers in Higher Education'

Day 3: **Saturday 20 March 2010**

Future directions: What makes teachers in HE to develop, what is the impact of teacher training

Format: Debate aimed at preparing research proposal(s), later work in groups if more than one research project is to be prepared

Chair: G. Pleschová
Record-keeper: E. Simon

Session 1
Scientific objectives of the research project, project methodology

Purpose of the session:
To elaborate a collaborative research initiative that will focus on evaluating the impact of teacher training on student learning with a stress on methodology

8:30
Presentation of draft proposal

9:00
Discussion

10:30
Break

Session 2:
Involved institutions and researchers, resources and research environment

10:50
Discussion

13:00
Lunch

14:30
Concluding remarks

Participants

- Gabriela Pleschová, *Eurea, Slovak Republic* (Convenor)
- Eszter Simon, *Slovak Academy of Sciences / University of Szeged* (Co-convenor)
- Joanna Renc-Roe, *Central European University, Hungary* (Co-convenor)
- Terry Barrett, *University College Dublin, Ireland*
- Erkki Berndtson, *University of Helsinki, Finland*
- Vicky Davies, *University of Ulster, United Kingdom*
- Andreas Frijdal, *European University Institute, Italy*
- Chris Goldsmith, *De Montfort University, United Kingdom*
- David Jaques, *Oxford Brookes University, United Kingdom*
- Mari Karm, *University of Tartu, Estonia*
- Balász Kiss, *European Science Foundation, France* (ESF Representative)
- Christopher Knapper, *Queen's University, Canada*
- Stéphane Labranche, *Pierre-Mendès-France University, France*
- Per Lauvås, *University of Oslo, Norway*
- Sarah Maguire, *University of Ulster, United Kingdom*
- Jennifer Murphy, *University College Cork, Ireland*
- Anne Nevgi, *University of Helsinki, Finland*
- Lin Norton, *Liverpool Hope University, United Kingdom*
- Christine Rabl, *University of Vienna, Austria*
- Torgny Roxa, *Lund University, Sweden*
- Uršula Szaboová, *Slovak Academy of Sciences, Slovakia* (Local Organiser)
- Keith Trigwell, *University of Sydney, Australia*

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December 2012 – Print run: 500

Designing and organizing blended course

Stefan Stenbom, stkn@kth.se

Slides available at: https://kth.box.com/v/EEE17-online

Stefan Stenbom, KTH Royal Institute of Technology

Some of the slides presented here was originally developed by
Marti Cleveland-Innes, Athabasca University
Norm Vaughn, Mount Royal University
Johan Fridell, KTH Royal Institute of Technology

Dr. Stefan Stenbom

Lecturer in Online and Blended Learning

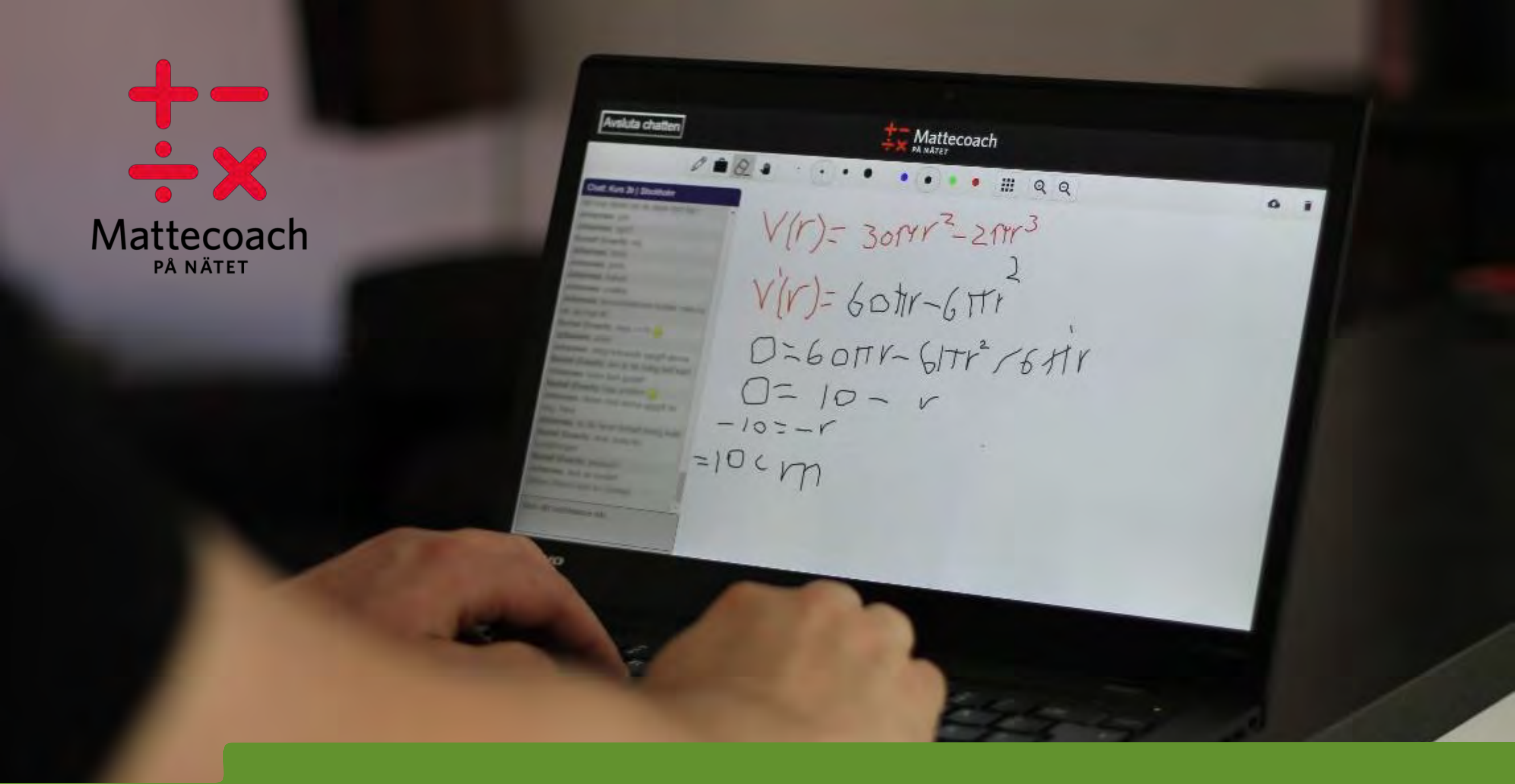
Owner of the E-learning portfolio at KTH

Teach courses in online and blended for teachers in K-12 and higher education. Director of Studies in the Technology for Learning unit.

Master of Science, Engineering & Education

Ph.D. about online learning

Mattecoach
PÅ NÄTET



MathCoach

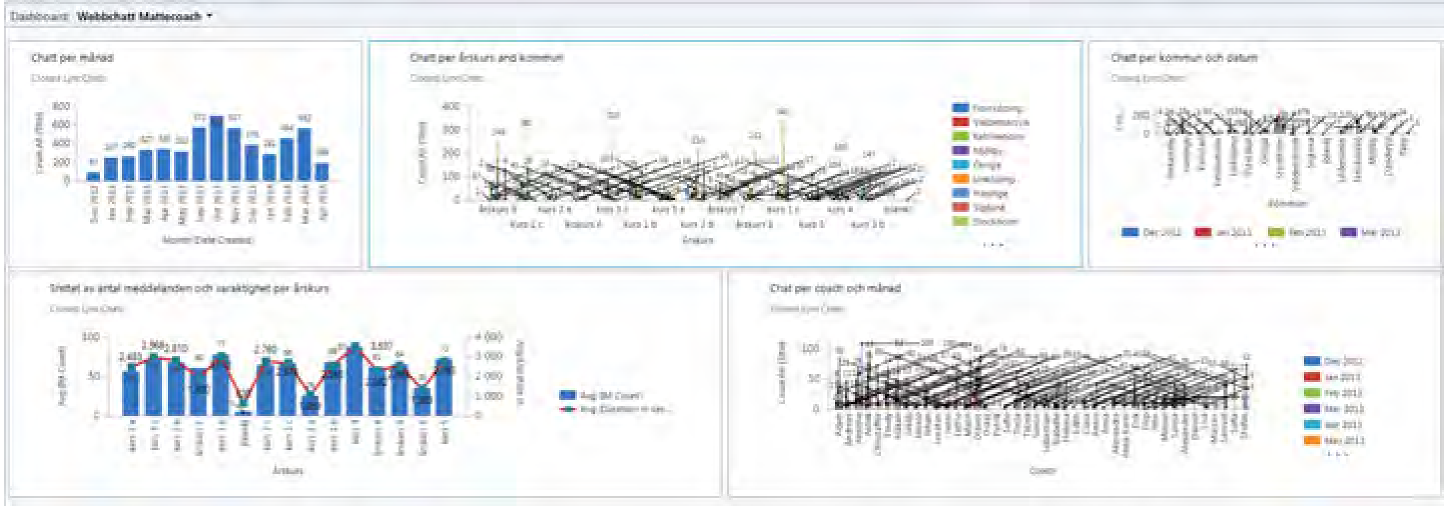
- Started in 2009.
- Open 5 pm - 8 pm every Monday to Thursday during semesters.
- Coachees range from sixth to ninth year of compulsory school, and upper secondary school (aged 12–19).
- Coaches are enrolled from KTH, Stockholm university, Linköping university and University of Gothenburg.

All transcripts are archived

Mattecoach
PÅ NÄTET

34 000 conversations

Average 40 minutes per conversation



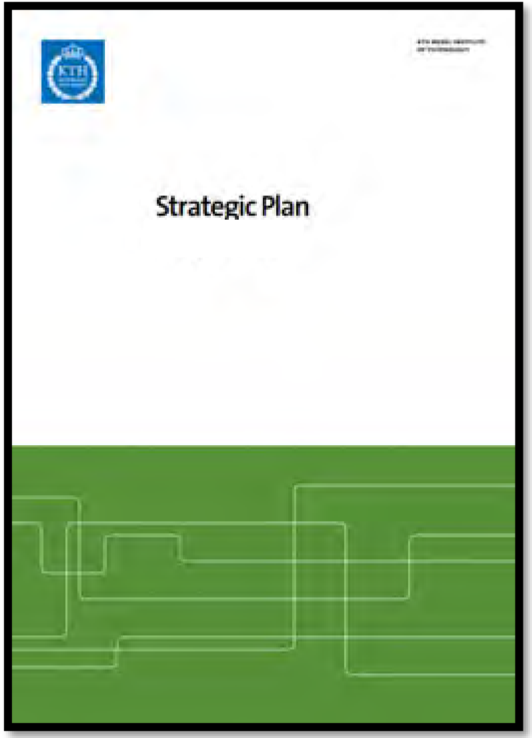
What is your experience of online and blended learning?

RATIONALE

The opportunities opened up by e-learning technologies have been incorporated, and the virtual campus is as important as its physical equivalent.

RATIONALE

The generation that is now looking to higher education have grown up with the Internet as a natural part of life, and there are rapid developments in e-learning. Consequences for universities who do not respond to this development may be significant.



Overall objective

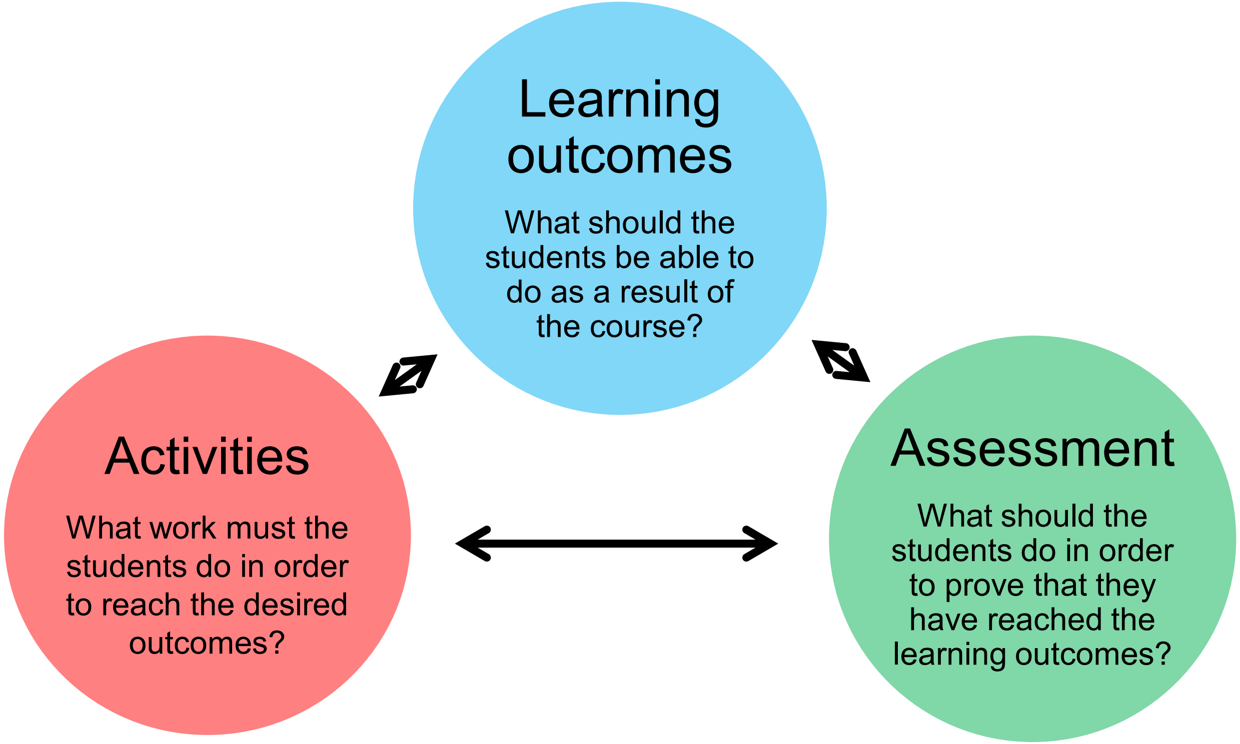
- *E-learning to be an integral part of kth educational programmes.*

KTH DEFINITION

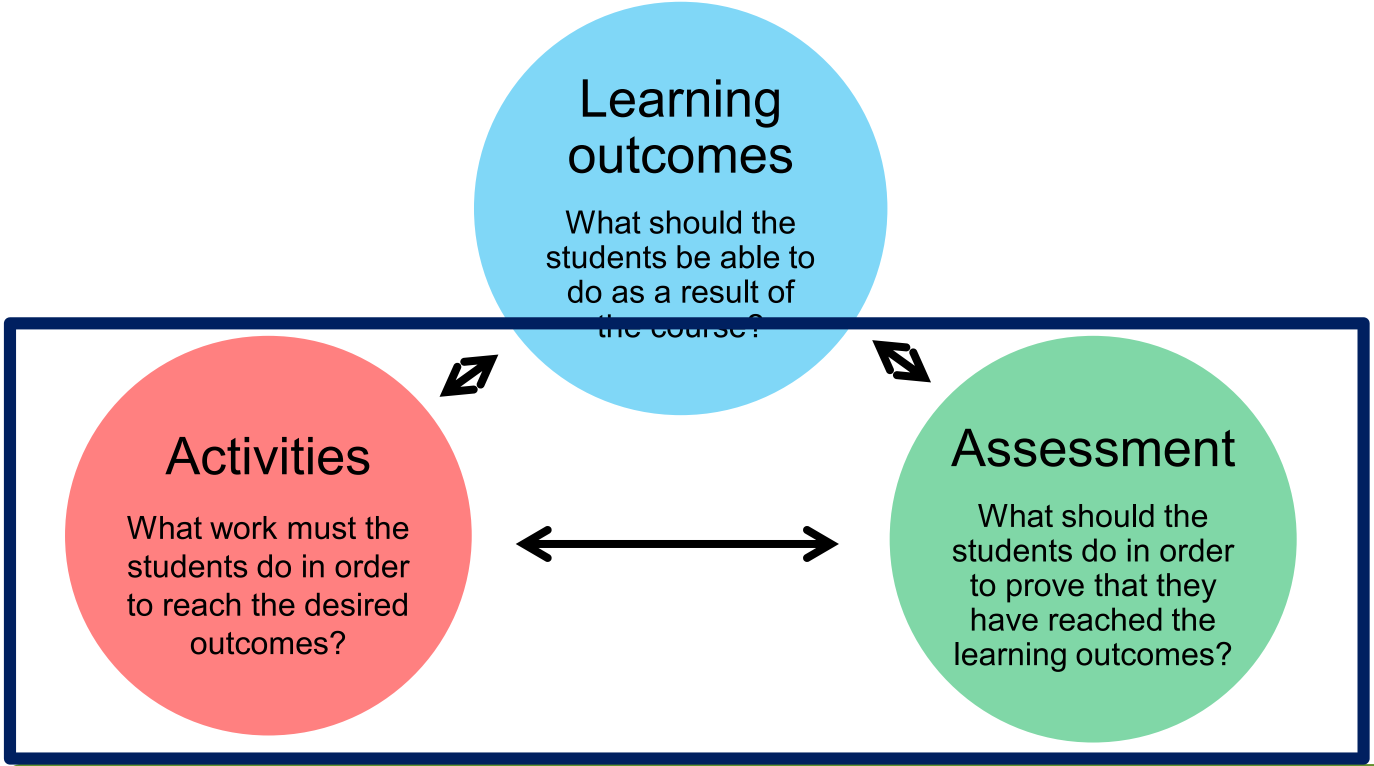
E-learning is defined as teaching with the support of technology. This includes using the Internet for *learning activities, assessment,* and systems used for *educational administration* used by teachers.

How does our rational relate to yours?

Constructive alignment



Constructive alignment



Examples

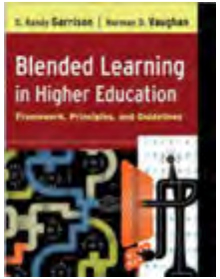
	Activities	Assessment
Face-to-face	• Attend a Lecture • Participate in a seminar • Read a Book • Perform a Laboration • Solve problems from old exams. • Participate in a tutoring sessions	• Written examination • Oral examination • Home exam • Clickers. • Self reflecting journal.
Online	• Watch a video lecture • Attend a webinar • Read an e-book. • Perform a virtual or remote Laboration	• Digital written examination • Online quizzes • Online assignments • Self reflecting blog

Blended Learning

. . . organic integration of thoughtfully selected and complementary face-to-face and online approaches and technologies.

. . . an opportunity to fundamentally redesign how we approach teaching and learning in ways that higher education institutions may benefit from increased *effectiveness, convenience and efficiency*.

(Garrison & Vaughan, 2008)



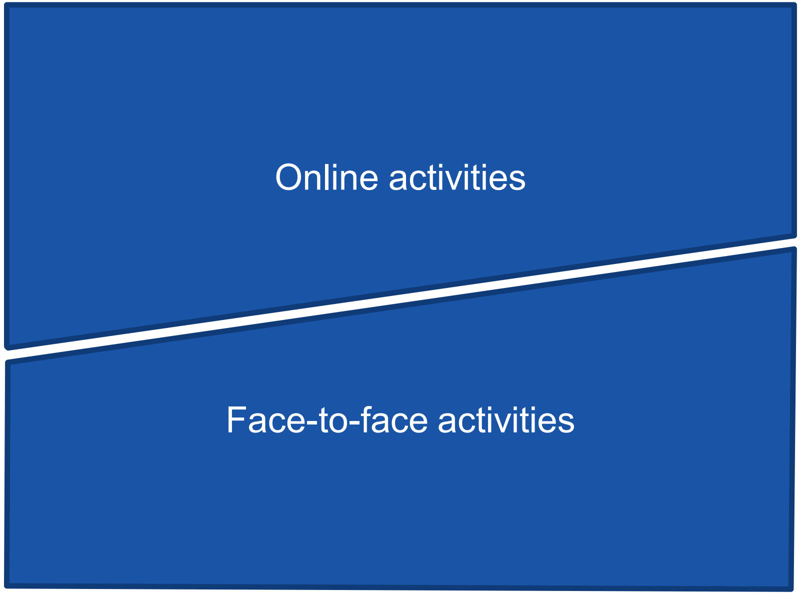
Blended learning environment

A learning environment expanded to also include

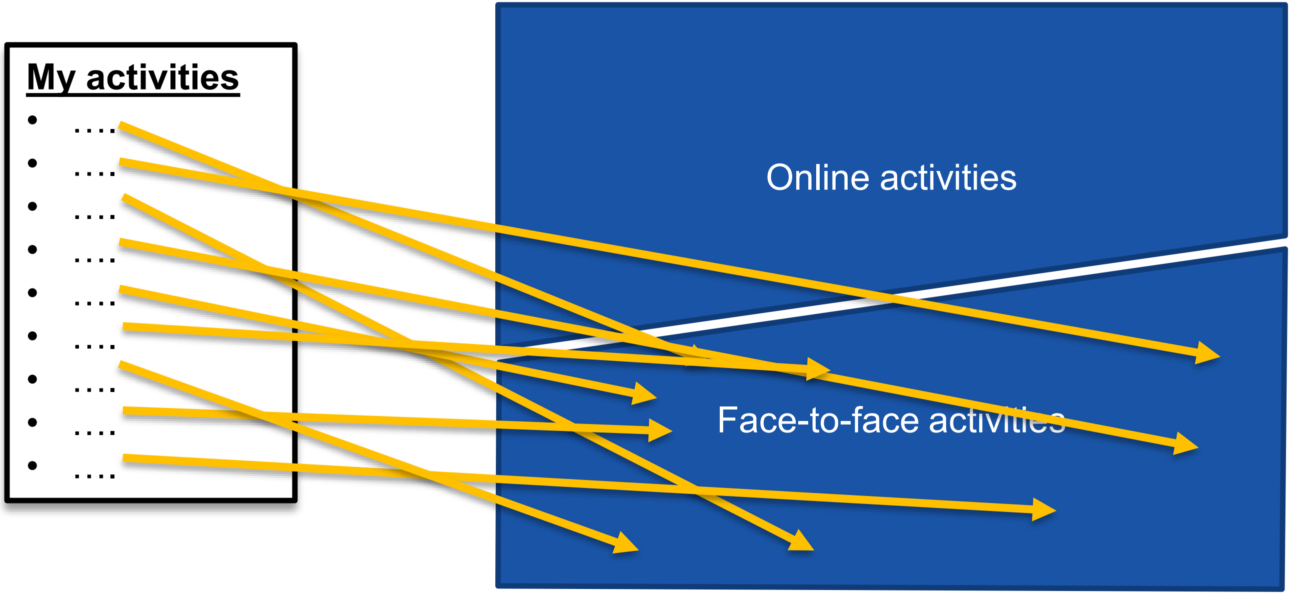
- Information
- Communication
- Administration

Supported by digital technology.

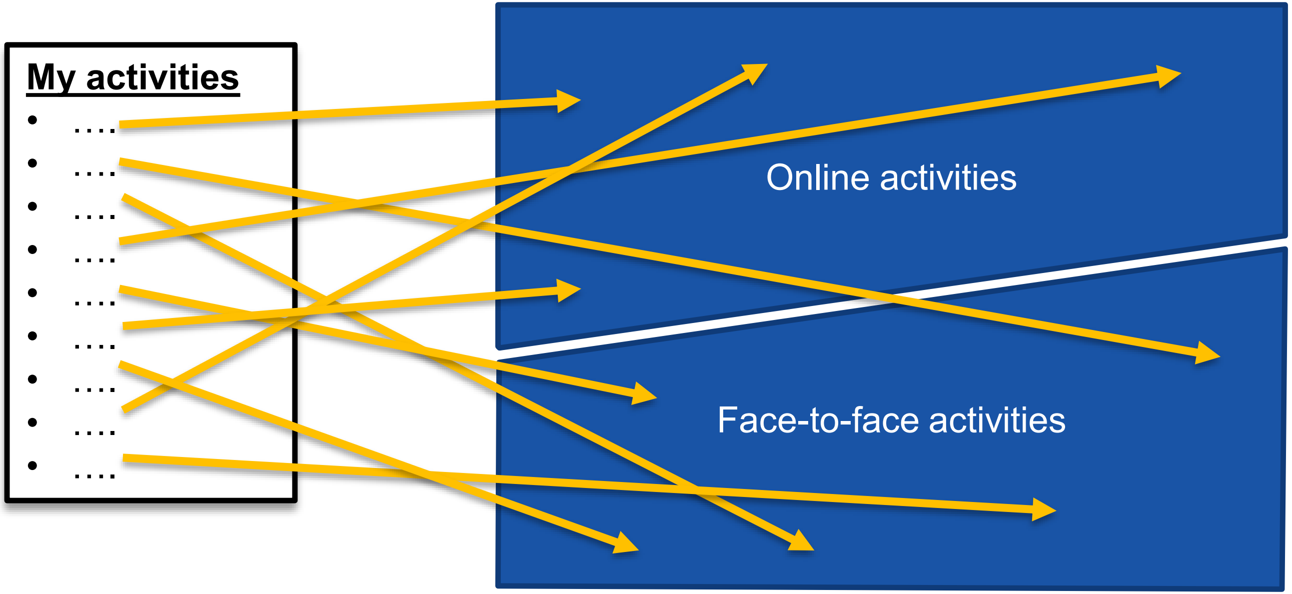
Learning activities



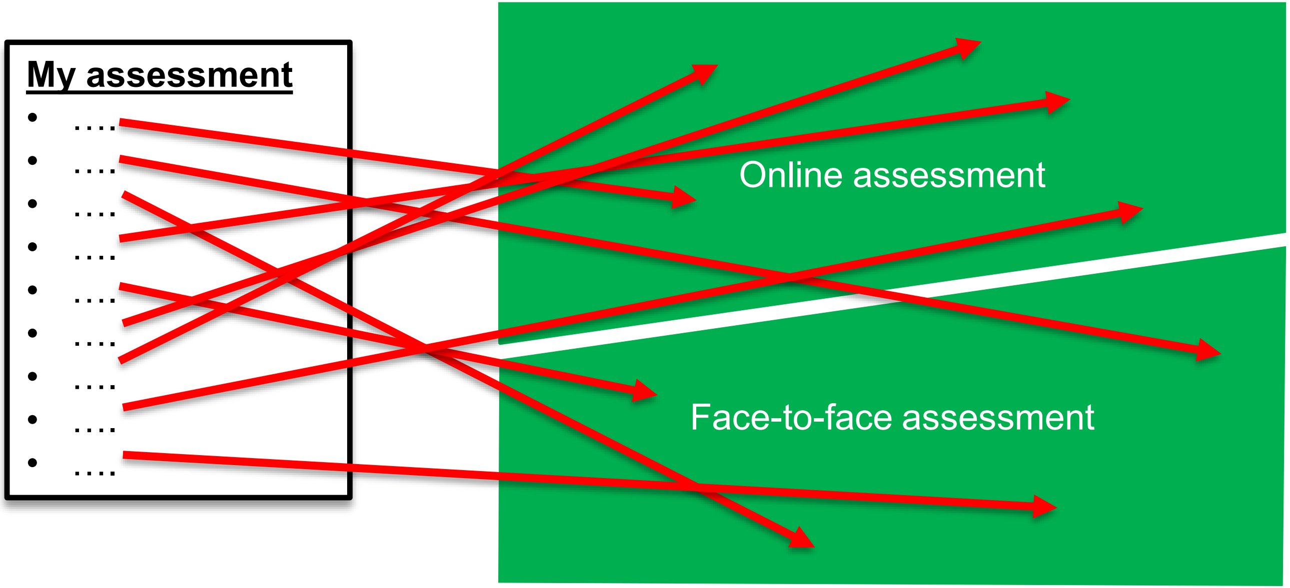
Learning activities



Learning activities



Assessment



Time and Place

	Same location	Difference location
Same time	**Face-to-face**	**Synchronous online learning**
Different time		**Asynchronous online learning**

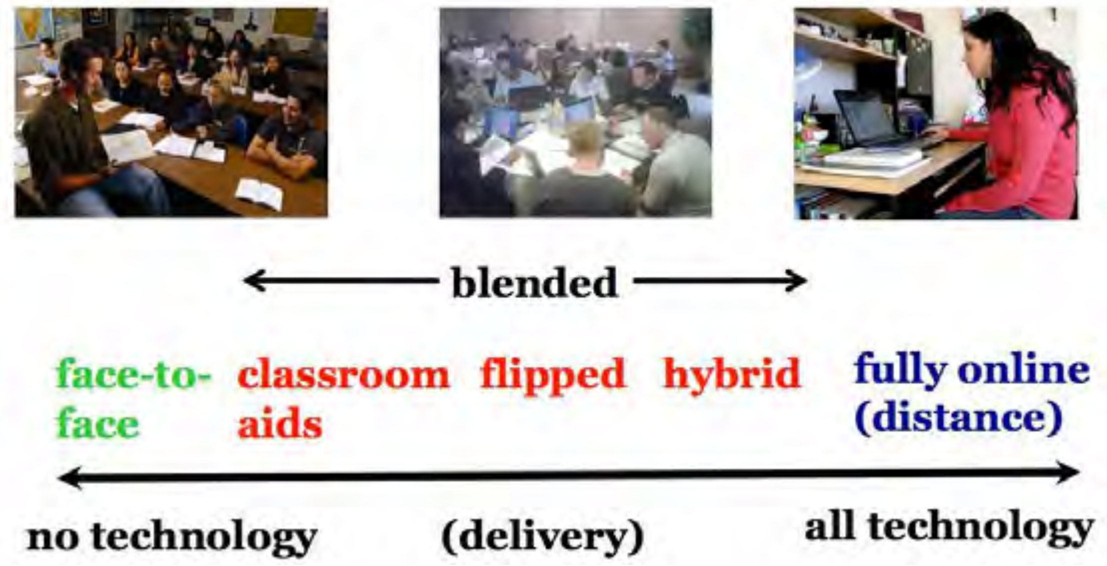


Figure by Tony Bates licensed under CC BY-NC 4.0

Online

(80+% of the content delivered online):

A course where most or all of the content is delivered online. Typically have no face-to-face meetings.

Blended

(30 to 79% of the content delivered online):

A course that blends online and face-to-face delivery. Substantial proportion of the content is delivered online, typically uses online discussions, and typically has a reduced number of face-to-face meetings.

Traditional / Web-facilitated

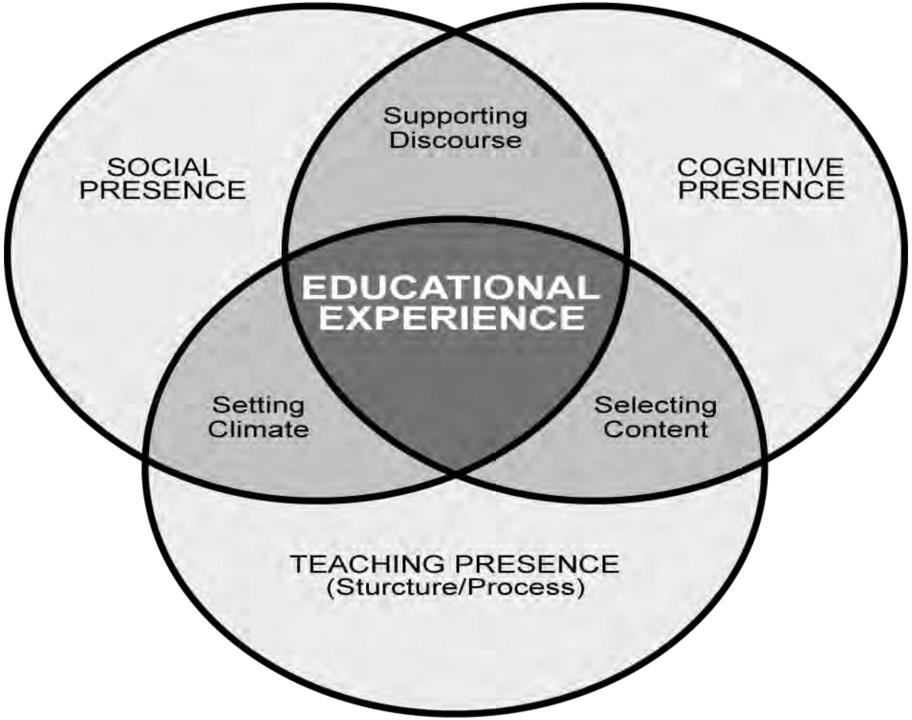
(0 to 29% of the content delivered online):

A course that uses little or no online technology - content is delivered in writing or orally, or uses web-based technology to facilitate what is essentially a face-to-face course. Examples of this might be posting the syllabus or list of assignments on a web page or to a course management system.

What is your view on online vs. blended vs. face-to-face?

Collaborative (Social) – Constructivist

Community of Inquiry



Communication Medium

A **community** is a social unit of any size that shares common values.

An **inquiry** is any process that has the aim of augmenting knowledge, resolving doubt, or solving a problem.

A **community of inquiry** is broadly defined as any group of individuals involved in a process of empirical or conceptual inquiry into problematic situations.

Community of inquiry 2013-05-11 10-24

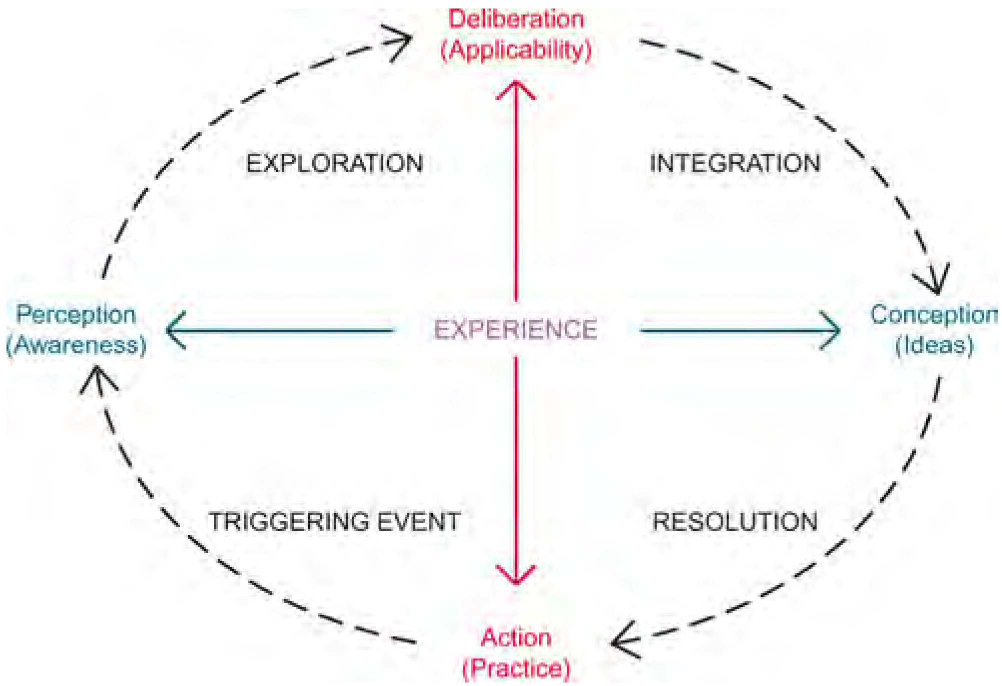
User:Eihpossophie - Own work

KTH VETENSKAP OCH KONST


phpBB
creating communities
yourdomain.com
A short text to describe your forum
Search...
Search
Advanced search
Board index
User Control Panel (0 new messages) • View your posts
FAQ
Members
Logout [Meow]
It is currently Thu Dec 13, 2007 5:36 pm
[Moderator Control Panel]
Last visit was: Thu Dec 13, 2007 5:35 pm
View unanswered posts • View new posts • View active topics
Mark forums read
YOUR FIRST CATEGORY
TOPICS
POSTS
LAST POST
Your first forum
Description of your first forum.
1
1
by Meow
on Thu Dec 13, 2007 5:35 pm
WHO IS ONLINE
In total there are 2 users online :: 1 registered, 0 hidden and 1 guest (based on users active over the past 5 minutes)
Most users ever online was 2 on Thu Dec 13, 2007 5:35 pm
Registered users: Meow
Legend: Administrators, Global moderators
STATISTICS
Total posts 1 • Total topics 1 • Total members 1 • Our newest member Meow
Board index
The team • Delete all board cookies • All times are UTC
Powered by phpBB © 2000, 2002, 2005, 2007 phpBB Group
Administration Control Panel


Magnus Gunnarsson
Professionalism – en fråga om tillit | Debatt

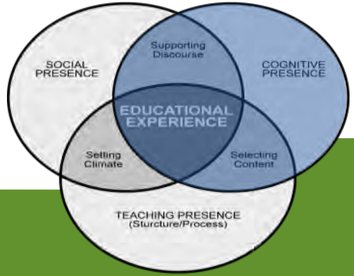
The Practical Inquiry Model



Cognitive Presence

Cognitive Presence is the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse (Garrison, Anderson, & Archer, 2001).

Triggering event → Exploration → Integration → Resolution



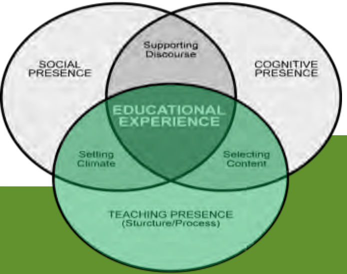
Teaching Presence

Teaching Presence is the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes (Anderson, Rourke, Garrison, & Archer, 2001).

Design & Organization

Facilitating Discourse

Direct Instruction



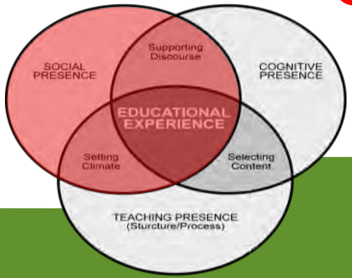
Social Presence

Social presence is “the ability of participants to identify with the community (e.g., course of study), communicate purposefully in a trusting environment, and develop inter-personal relationships by way of projecting their individual personalities.” (Garrison, 2009)

Personal/ Affective

Open Communication

Group Cohesion



Research methods for analysis

- Transcript coding
- Standardized survey

Transcript coding

Elements	Categories	Indicators (examples only)
Cognitive Presence	Triggering Event	Sense of puzzlement
	Exploration	Information exchange
	Integration	Connecting ideas
	Resolution	Apply new ideas
Social Presence	Emotional Expression	Emoticons
	Open Communication	Risk-free expression
	Group Cohesion	Encouraging collaboration
Teaching Presence	Instructional Management	Defining & initiating discussion topics
	Building Understanding	Sharing personal meaning
	Direct Instruction	Focusing discussion

(Garrison, Anderson, & Archer, 2000, p. 4)

Standardized survey

Community of Inquiry Survey Instrument (draft v14)

Teaching Presence

Design & Organization

1. The instructor clearly communicated important course topics.

2. The instructor clearly communicated important course goals.

3. The instructor provided clear instructions on how to participate in course learning activities.

4. The instructor clearly communicated important due dates/time frames for learning activities.

Facilitation

5. The instructor was helpful in identifying areas of agreement and disagreement on course topics that helped me to learn.

6. The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.

7. The instructor helped to keep course participants engaged and participating in productive dialogue.

8. The instructor helped keep the course participants on task in a way that helped me to learn.

9. The instructor encouraged course participants to explore new concepts in this course.

10. Instructor actions reinforced the development of a sense of community among course participants.

Direct Instruction

11. The instructor helped to focus discussion on relevant issues in a way that helped me to learn.

12. The instructor provided feedback that helped me understand my strengths and weaknesses.

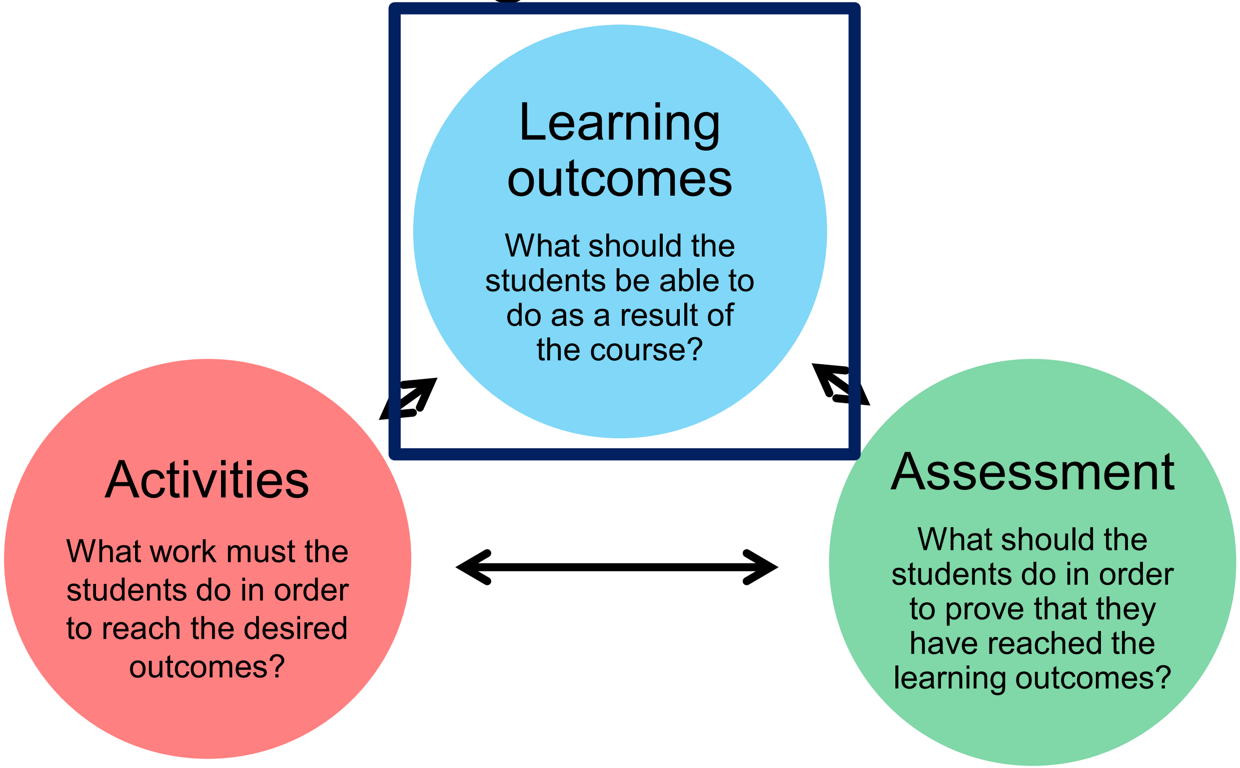
13. The instructor provided feedback in a timely fashion.

ITBL CHART

http://tinyurl.com/ITBL-OCT17

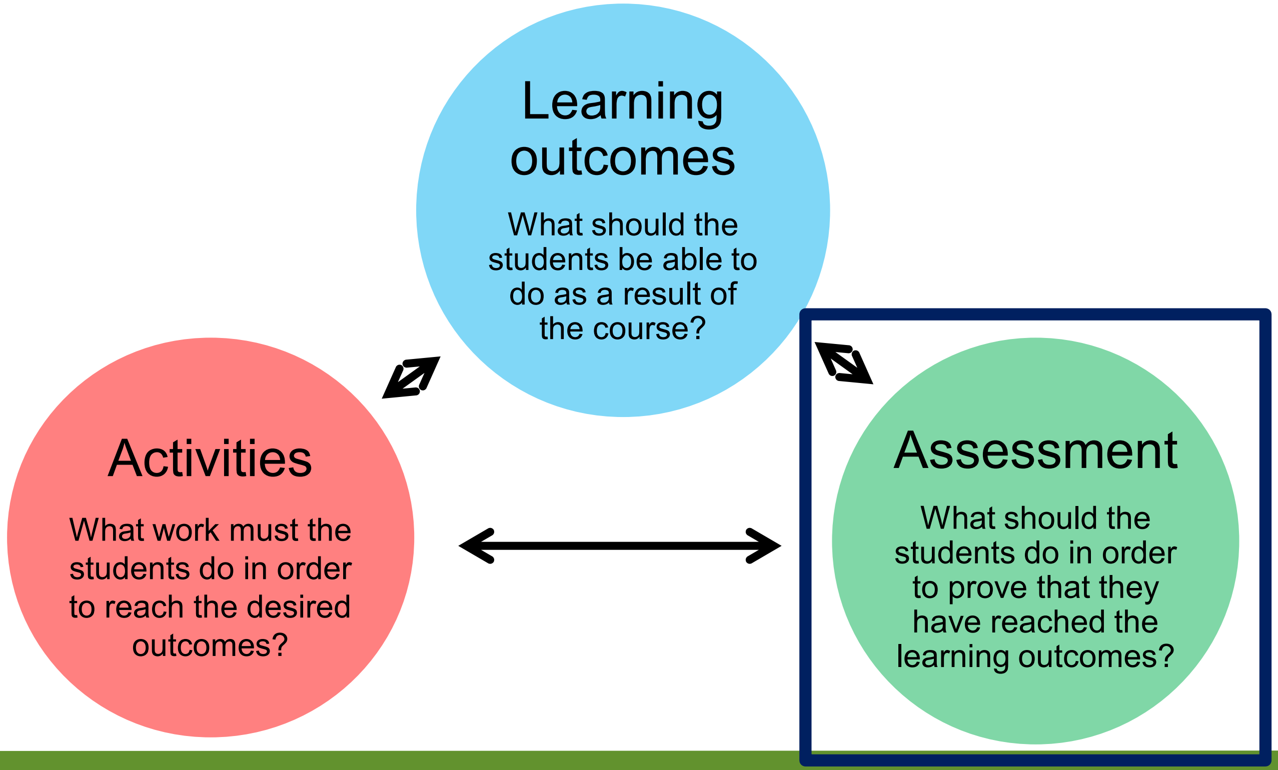
Think of this week as a course

Constructive Alignment



What do you want your students to know when they have finished your module (e.g. key learning outcomes – knowledge, skills and attitudes)?

Constructive Alignment



Examples

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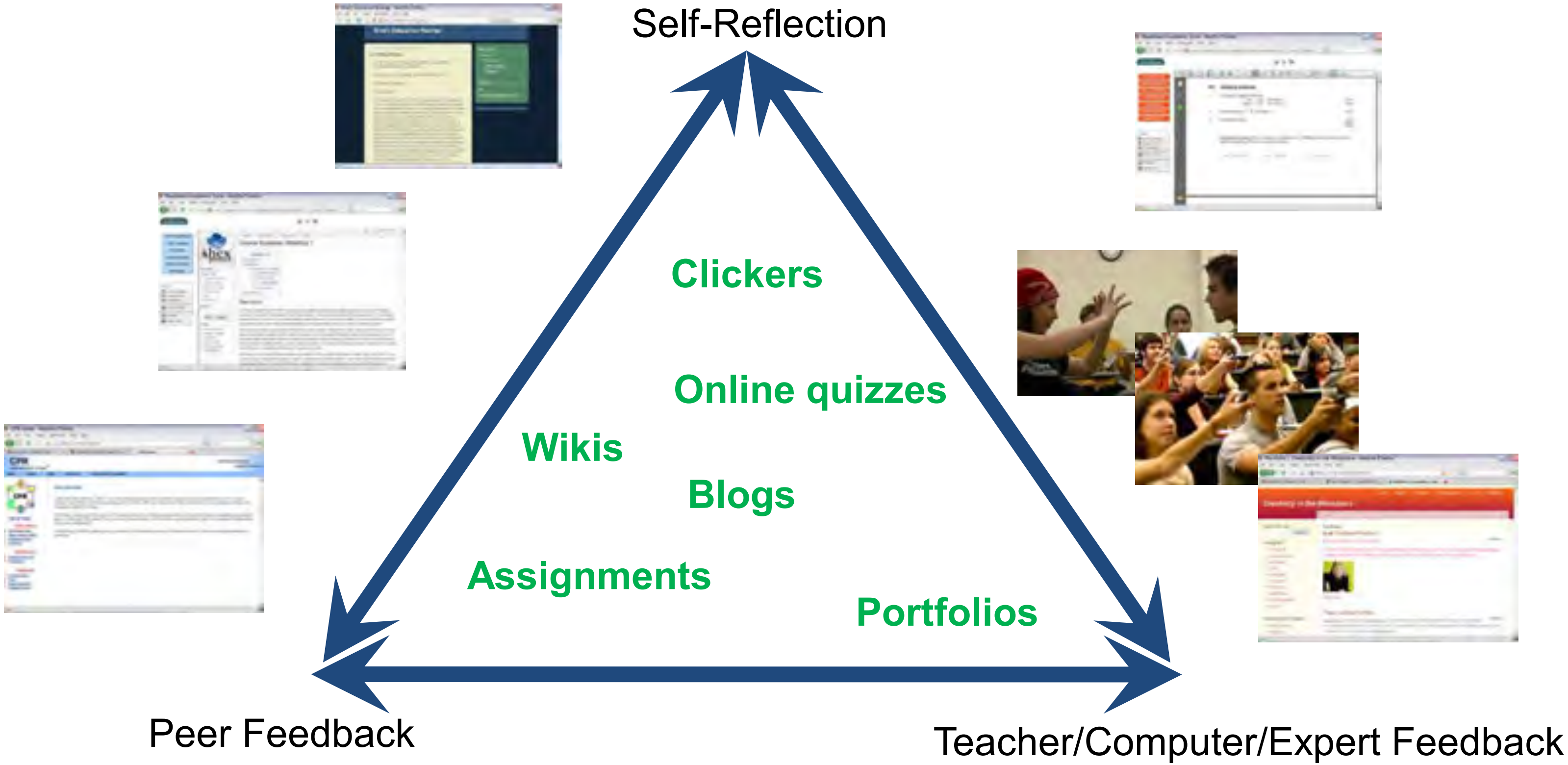
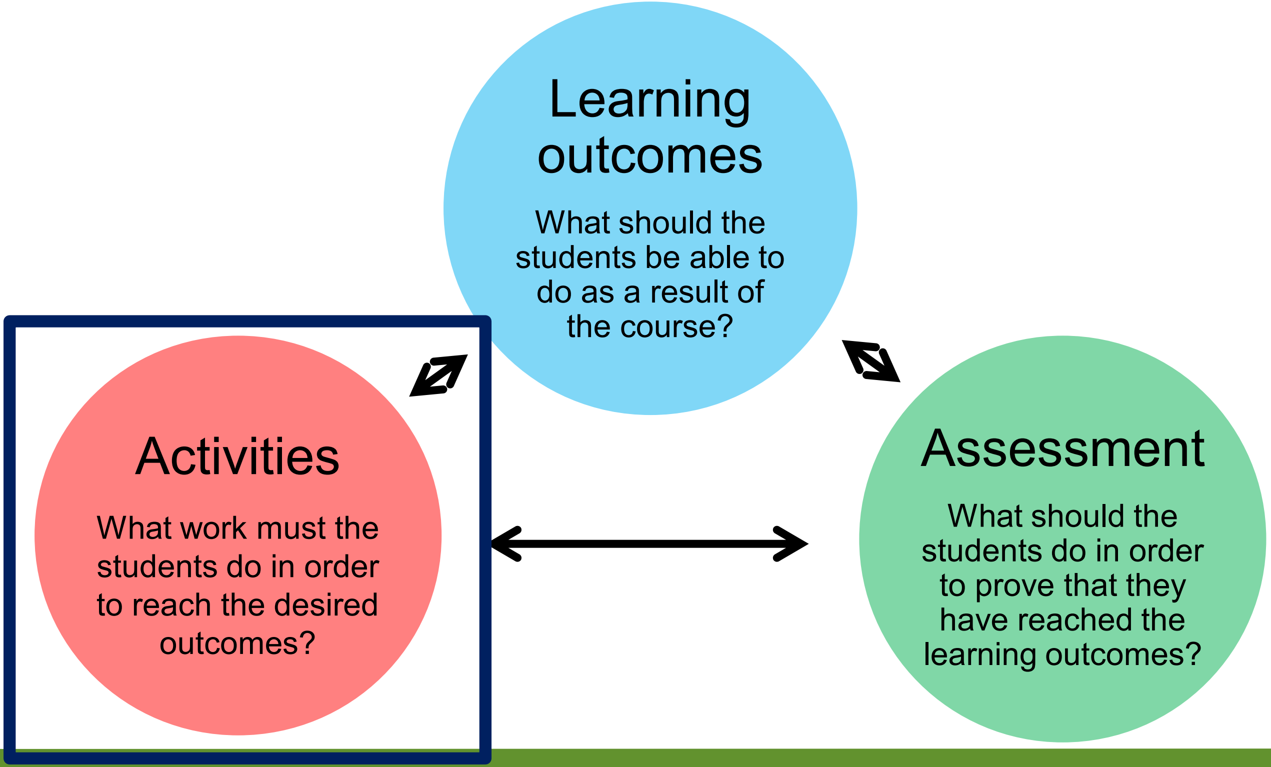
Assessment Triad Approach



How will you and your students know if they have achieved these learning outcomes (e.g. opportunities for self, peer, and instructor assessment)?

Constructive Alignment



Examples

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Activity structure

Asynchronous learning activity

Synchronous learning activity

(Face-to-face or online)

Asynchronous learning activity

CONCEIVE DESIGN IMPLEMENT OPERATE

The CDIO approach
for engineering education development

Kristina Edström
KTH Royal Institute of Technology, Stockholm, Sweden

Kristina Edström

Engineer & Educational developer

- M. Sc. in Engineering, Chalmers
- Associate Professor in *Engineering Education Development* at KTH Royal Institute of Technology, Stockholm, Sweden
- 700 participants in the 7.5 ECTS course *Teaching and Learning in Higher Education*, customized for KTH faculty, 2004-2012
- Director of Educational Development at Skolkovo Institute of Science and Technology, Moscow, 2012-2013

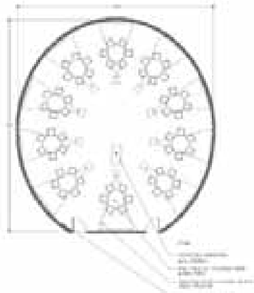
Strategic educational development, national and international

- CDIO Initiative for reform of engineering education since 2001
- SEFI Administrative Council, 2010-2013

CONCEIVE DESIGN IMPLEMENT OPERATE

Research

- PhD defense December 13, 2017
- Editor-in-Chief of the *European Journal of Engineering* Education from 2018
- Crawley, E.F., Malmqvist, J., Östlund, S., Brodeur, D.R., and Edström, K. (2014) *Rethinking Engineering Education: The CDIO Approach*, 2nd ed., Springer Verlag
- Edström, K., & Kolmos, A. (2014). PBL and CDIO: complementary models for engineering education development. *European Journal of Engineering Education*, 39(5), 539-555
- Edström, K. (2008) Doing course evaluation as if learning matters most, *Higher Education Research & Development*, 27:2, 95 – 106



“If you want to learn about a system, try to change it”

(after Le Chatelier’s principle)

What is CDIO?

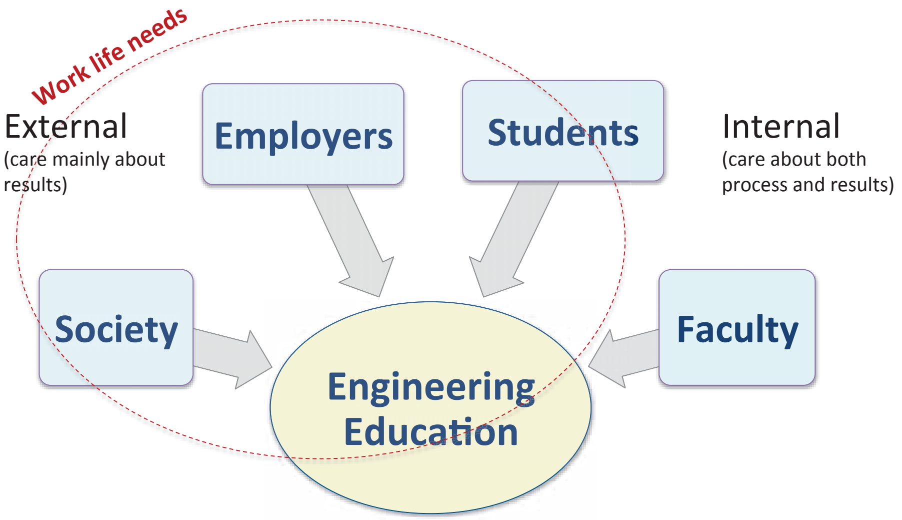
1. An idea of what engineering students should learn and why

“Engineers who can engineer”

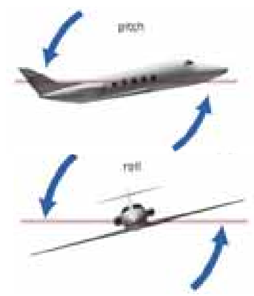
cdio

CONCEIVE DESIGN IMPLEMENT OPERATE

Stakeholder perspectives



An education *about* technology



NECESSARY BUT NOT SUFFICIENT

An education *in* engineering

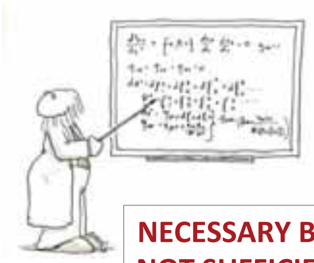
Conceive: customer needs, technology, enterprise strategy, regulations; and conceptual, technical, and business plans

Design: plans, drawings, and algorithms that describe what will be implemented

Implement: transformation of the design into the product, process, or system, including manufacturing, coding, testing and validation

Operate: the implemented product or process delivering the intended value, including maintaining, evolving and retiring the system

Disciplinary theory applied to "problem-solving"



NECESSARY BUT NOT SUFFICIENT

Theory and judgement applied to <u>real</u> problems

- Cross disciplinary boundaries
- Sit in contexts with societal and business aspects
- Complex, ill-defined and contain tensions
- Need interpretations and estimations ('one right answer' are exceptions)
- Require systems view

Jonassen, D., Strobel, J., & Lee, C. B. (2006). Everyday problem solving in engineering: Lessons for engineering educators. *Journal of Engineering Education*, 95(2), 139.

Individual approach

NECESSARY BUT NOT SUFFICIENT

Communicative and collaborative approach

- Crucial for all engineering work processes
- Much more than working in project teams with well-defined tasks
- Engineering is a social activity involving customers, suppliers, colleagues, citizens, authorities, competitors
- Networking within and across organizational boundaries, over time, in a globalised world

CDIO Standard 1: The context

Educating for the context of engineering

Education set in *Engineering science*

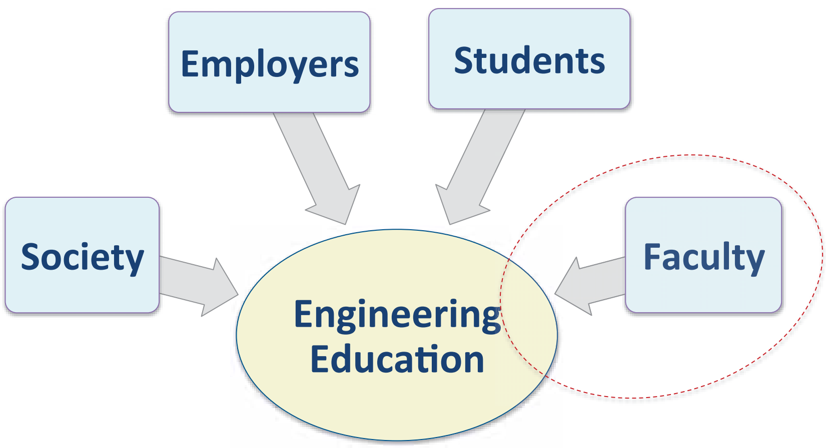
NECESSARY BUT NOT SUFFICIENT

Educate for the context of *Engineering*

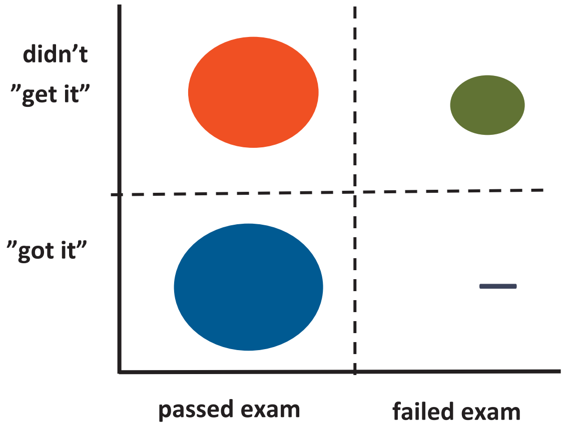
CDIO Standard 1 – The context
Adoption of the principle that product, process, and system lifecycle development and deployment – *Conceiving, Designing, Implementing and Operating* – are the context for engineering education.

Engineers who can engineer!

But what if we do ask faculty?



Deeper working knowledge of disciplinary fundamentals



- Functional knowledge
- Not just reproduction of known solutions to known problems
- Conceptual understanding
- Being able to explain what they do and why

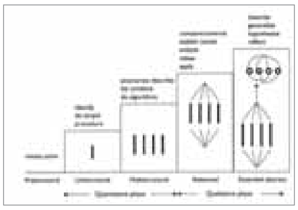
See for instance Mazur, E. (1997) *Peer Instruction*, and Kember & McNaught (2007) *Enhancing University Teaching*.

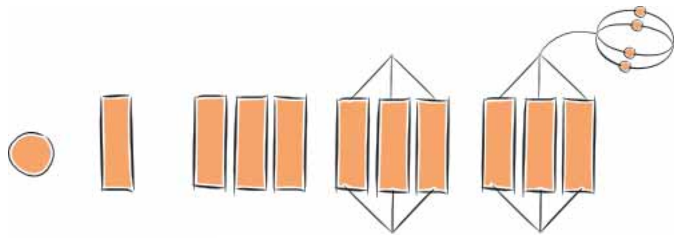
Quality of student learning – Feisel-Schmitz Technical Taxonomy

Judge	To be able to critically evaluate multiple solutions and select an optimum solution
Solve	Characterize, analyze, and synthesize to model a system (provide appropriate assumptions)
Explain	Be able to state the process/outcome/concept in their own words
Compute	Follow rules and procedures (substitute quantities correctly into equations and arrive at a correct result, "plug & chug")
Define	State the definition of the concept or describe in a qualitative or quantitative manner

[Feisel, L.D., Teaching Students to Continue Their Education, *Proceedings of the Frontiers in Education Conference*, 1986.]

The SOLO taxonomy
– more useful classifications





[Biggs and Collis, 1982; Image by Pam Hook]

Adapting CDIO to Civil Engineering:
Investigate – Plan – Design – Construct – Operate and maintain

Martin Nilsson
Luleå University of Technology

Catrin Edelbro
Luleå University of Technology

Kristina Edström
KTH Royal Institute of Technology

What is CDIO?

2. A methodology for engineering education reform

The 12 CDIO Standards

CONCEIVE DESIGN IMPLEMENT OPERATE

Success

is never inherent in a method;
it always depends on
good implementation.

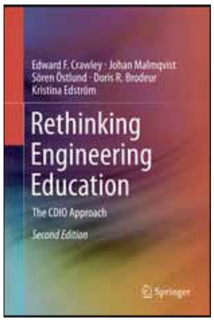
The educational development process is the working definition of CDIO:
The CDIO Standards

Context:
- Recognise that we educate for the practice of engineering [1]

Curriculum development:
- Formulate explicit program learning outcomes (including engineering skills) in dialogue with stakeholders [2]
- Map out responsibilities to courses – negotiate intended learning outcomes [3]
- Evaluation and continuous programme improvement [12]

Course development, discipline-led and project-based learning experiences:
- Introduction to engineering [4]
- Design-implement experiences and workspaces [5, 6]
- Integrated learning experiences [7]
- Active and experiential learning [8]
- Learning assessment [11]

Faculty development
- Engineering skills [9]
- Skills in teaching & learning , and assessment [10]



Crawley, et al (2007, 2014) *Rethinking Engineering Education: The CDIO Approach*, Springer.

CDIO Standard 2: Learning Outcomes
Recognising the dual nature of learning

Understanding of technical fundamentals and **Professional engineering skills**

CDIO Standard 2 – Learning Outcomes
Specific, detailed learning outcomes for personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge, consistent with program goals and validated by program stakeholders.

The CDIO Syllabus
Support in formulating learning outcomes

Each institution formulates program goals considering their own stakeholder needs, national and institutional context, level and scope of programs, subject area, etc

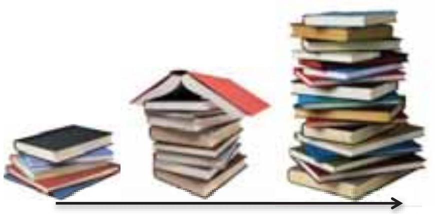
The CDIO Syllabus
- is not prescriptive (not a CDIO Standard)
- is offered as an instrument for specifying local program goals by selecting topics and making appropriate additions in dialogue with stakeholders
- lists and categorises desired qualities of engineering graduates
- is based on stakeholder input and validation

- Crawley, E. F. 2001. *The CDIO Syllabus: A Statement of Goals for Undergraduate Engineering Education: see* www.cdio.org/framework-benefits/cdio-syllabus-report
- for version 2.0, see Crawley, Malmqvist, Lucas, and Brodeur. 2011. "The CDIO Syllabus v2.0. An Updated Statement of Goals for Engineering Education." *Proceedings of the 7th International CDIO Conference*

The strategy of CDIO is integrated learning of knowledge and skills

!

Standard 3 – Integrated curriculum
Integrating the two learning processes



Acquisition of technical knowledge

Development of engineering skills

The CDIO strategy is the **integrated curriculum** where knowledge & skills give each other meaning!

CDIO Standard 3 – Integrated Curriculum
A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal, interpersonal, and product, process, and system building skills.

Every learning experience sets a balance and relationship

Discipline-led learning

- Well-structured knowledge base
- Evidence/theory, Model/reality
- Methods to further the knowledge frontier

CONNECTING WITH PROBLEM/ PRACTICE

- Deep working understanding = ability to apply
- Seeing the knowledge through the lens of problems, interconnecting the disciplines
- Integrating skills, e.g. communication and collaboration

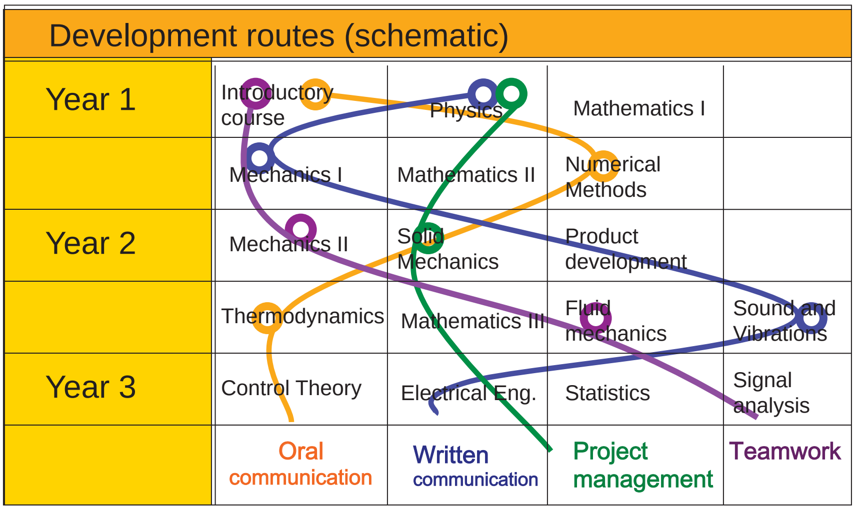
Problem/practice-led learning

- Integration and application, synthesis
- Open-ended problems, ambiguity, trade-offs
- Context
- Professional work processes
- ”Creating that which has never been”

CONNECTING WITH DISCIPLINARY KNOWLEDGE

- Discovering how the disciplinary knowledge is useful
- Reinforcing disciplinary understanding
- Motivational context

Systematic assignment of program learning objectives to courses - negotiating the contribution



Example: Communication skills in Lightweight design

Communication in lightweight design means being able to

- Use the technical concepts comfortably
- Discuss a problem of different levels
- Determine what factors are relevant to the situation
- Argue for, or against, conceptual ideas and solutions
- Develop ideas through discussion and collaborative sketching
- Explain technical matters to different audiences
- Show confidence in expressing oneself within the field

The skills are **embedded** in, and **inseparable** from, students' application of technical knowledge.

The same interpretation should be made for teamwork, problem solving, professional ethics, and other engineering skills.

"It's about educating engineers who can actually engineer!"

What does communication skills mean in the specific professional role or subject area?

[Barrie 2004]

Engineering skills - implications

- **It's not about "soft skills"**

  Personal, interpersonal, product, process, and system building skills are **intrinsic to engineering** and we should recognise them as **engineering skills**.

- **It's not about "adding more content"**

  Students must be given opportunities to develop communication skills, teamwork skills, etc. This is best achieved through **practicing, reflecting, giving and receiving feedback** (rather than lecturing on psychological and social theory).

- **It's not about "wasting credits"**

  When students practice engineering skills they apply and express their technical knowledge. As they expose their understanding among peers, doing well will also matter more to them. Students will develop **deeper working knowledge**.

- **It's not about appending "skills modules"**

  Personal, interpersonal, product, process, and system building skills must be practiced and assessed **in the technical context**, it cannot be done separately.

Place in curriculum	Faculty perception of generic 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.

Barrie, S. (2004) A research-based approach to generic graduate attributes policy, *Higher Education Research and Development*. 23 (3), 261-275

PROGRESSION

Enhancing progression through the curriculum

THE BLACK-BOX EXERCISE

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

OUTPUT:
→ **Contribution to final learning outcomes**
→ **Input to later course**
→ **Input to later course**
→ **Input to later course**

All faculty formulate their course only as input/output:

Input: "When students come to my course I want them to be able to..."
Output: "When students leave my course they will be able to... because I think this is necessary input for course X..."

Black-box exercise

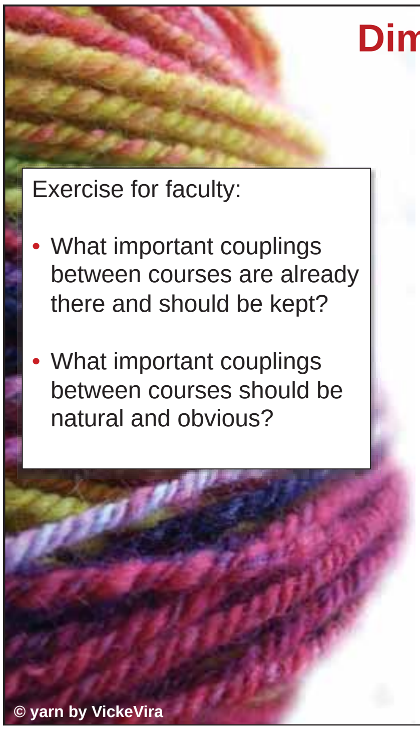
All courses are presented through input and output only:

- Enables efficient discussions
- Makes connections visible (as well as lack thereof)
- Gives all faculty an overview of the program
- Serves as a basis for improving coordination
- Use for adjusting intentions in planning phase
- Use for checking existing programs

During the discussions:

- Document which course takes responsibility for what learning outcomes
- Identify redundancies or gaps
- Check chronological order
- Is it easy for the students to make the connections between courses?

Dimensions of progression



Exercise for faculty:

- What important couplings between courses are already there and should be kept?
- What important couplings between courses should be natural and obvious?

- Subject content
- Personal, professional and engineering skills
- Theoretical maturity – not just ”more” theory, but to make connections and apply (integration, synthesis & modelling)
- Understanding context ("real" problems, sustainable development, ethics, etc)
- Selecting and applying methods, understanding limitations
- Professional "eye" and language (see and interpret situations, discuss with others and relate to knowledge)
- Academic writing, professional writing
- Personal development (feedback, reflection, etc)
- View on knowledge (not just black and white)
- Degree of independence as a learner (pedagogical red threads)

Course Design for Integrated Learning

Learning outcomes are the basis for course design

Formulating intended learning outcomes

What should the <u>students</u> be able to do as a result of the course?

Designing activities

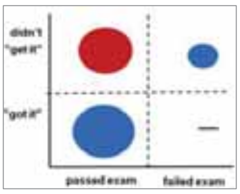
Designing assessment

Constructive alignment
[Biggs]

What work is appropriate for the <u>students</u> to do, to reach the learning outcomes?

How should the <u>students</u> demonstrate that they fulfil the learning outcomes?

Constructive alignment - applied



Formulating intended learning outcomes

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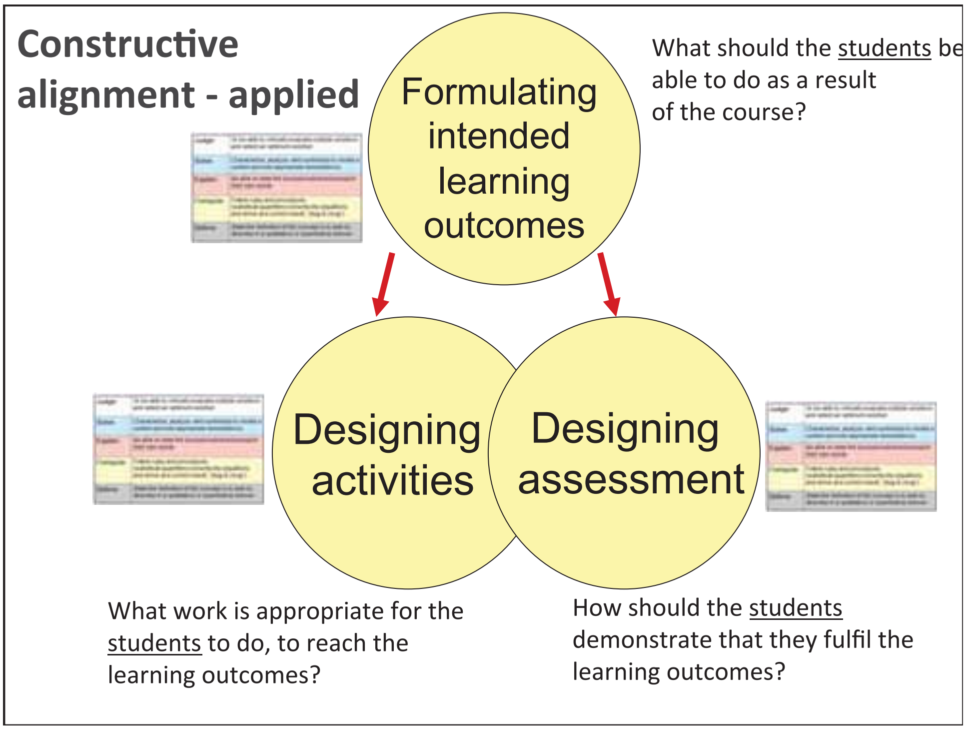
Constructive alignment - applied
Formulating intended learning outcomes
What should the students be able to do as a result of the course?
Designing activities
Designing assessment
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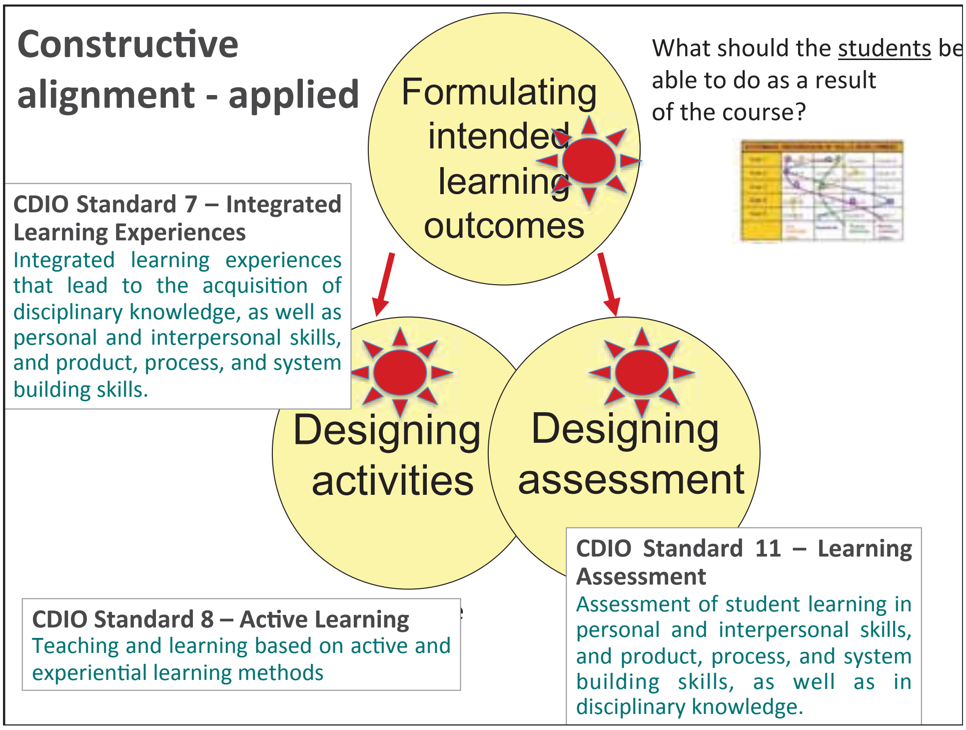

Constructive alignment - applied
Formulating intended learning outcomes
What should the students be able to do as a result of the course?
CDIO Standard 7 – Integrated Learning Experiences
Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process, and system building skills.
Designing activities
Designing assessment
CDIO Standard 8 – Active Learning
Teaching and learning based on active and experiential learning methods
CDIO Standard 11 – Learning Assessment
Assessment of student learning in personal and interpersonal skills, and product, process, and system building skills, as well as in disciplinary knowledge.

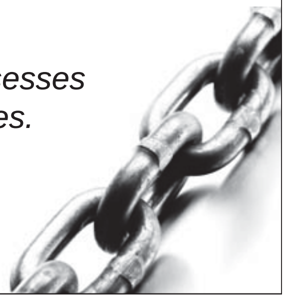
Our curriculum system has 2 logical links

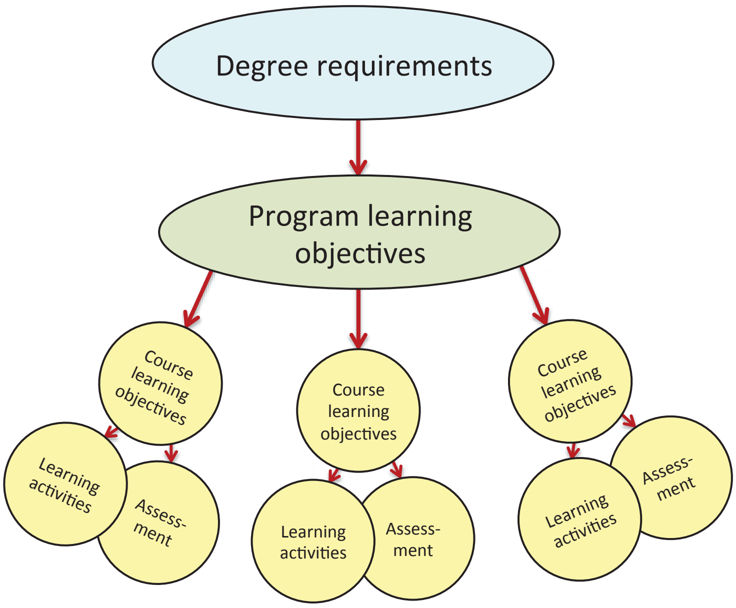
The strength of the chain – the extent to which graduates will actually meet the program learning objectives – hinges on:

- **the connection between courses and programs**
  that the sum of course learning objectives actually equals the program objectives,

and

- **the constructive alignment**
  that each course actually teaches and assesses students according to its learning objectives.





Anyone can improve a course if it means that the teacher works 100 hours more

That is not a valid solution…

This is about how to get better student learning from the same (finite) teaching resources

CDIO Standard 10 -- Enhancement of Faculty Teaching Competence
Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning.

Examples are illustrations of principles

A specific **example** will **illustrate** **generic principles** to **inspire** **applications** - of many different kinds.

Educational development strategies



Improving discipline-led learning

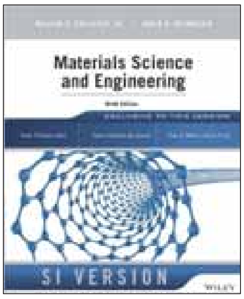
- Improving the quality of understanding
- Knowledge prepared for use: seeing the knowledge through the lense of problems
- Ability to communicate and collaborate
- Interconnecting the disciplines

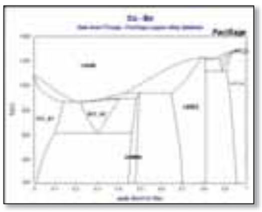
Improving problem/practice-based learning

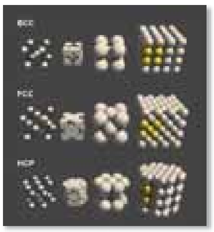
- Adding problem/practice-based learning experiences
  - Early engineering experience
  - A sequence of Design-Implement Experiences
- Improving reflection and learning
- Improving cost-effectiveness of teaching

A course in Basic Materials Science

- Standard lecture based course
- Focus on disciplinary knowledge ("content")







Hypoeutectoid steel was quenched from austenite to martensite which was tempered, spheroidized and hardened by dislocation pinning..

[Professor Maria Knutson Wedel, Chalmers]

A course in Basic Materials Science

Two ways of seeing materials science

From the inside - out

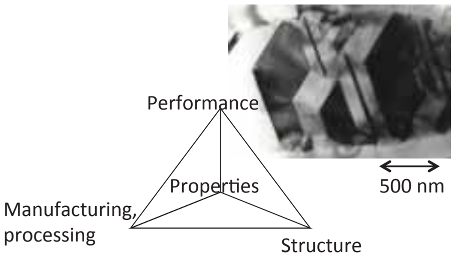
"Materials engineers distinguish themselves from mechanical engineers by their focus on the internal structure and processing of materials, specifically at the micro- and nano-scale."

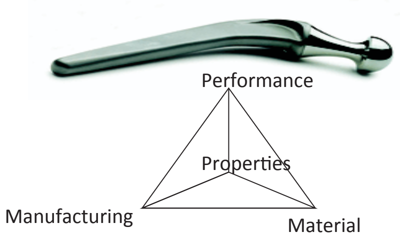
Flemings & Cahn

From the outside - in

"Materials have a supportive role of materializing the design. The performance is of primary concern, followed by considerations of related materials properties...."

Östberg





[Professor Maria Knutson Wedel, Chalmers]

A course in Basic Materials Science

Implications I
- formulating intended learning outcomes

Old learning objectives (the disciplinary knowledge in itself)

...describe crystal structures of some metals...

...interpret phase diagrams...

...explain hardening mechanisms...

...describe heat treatments...

New learning objectives (performances of understanding)

...select materials based on considerations for functionality and sustainability

...explain how to optimize material dependent processes (eg casting, forming, joining)

...discuss challenges and trade-offs when (new) materials are developed

...devise how to minimise failure in service (corrosion, creep, fractured welds)

[Professor Maria Knutson Wedel, Chalmers]

A course in Basic Materials Science

Implications II
- design of learning activities

Still lectures and still the same book, but framed differently:
- from product to atoms
- focus on engineering problems

And…
- Study visit in industry, assessed by written reflection
- Material selection class (CES)
- Active lecturing: buzz groups, quizzes
- Test yourself on the web
- Students developed animations to visualize

[Professor Maria Knutson Wedel, Chalmers]

A course in Basic Materials Science

Implications III
- design of assessment

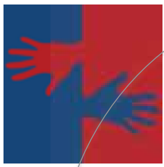
2011:
New type of exam, aimed at deeper working understanding
- More **open-ended questions** - many solutions possible, the quality of **reasoning** is assessed
- **Interconnected knowledge** – several aspects need to be integrated

➢*Very good results on the exam but some students were scared and there were many questions beforehand…*

2012:
Added formative midterm exam, with peer assessment
- Communicates expectations on the required **level and nature of understanding** (Feedback / Feed forward)
- Generates **appropriate learning activity**
- **Early engagement in the basics** of the course (a basis for further learning)

[Professor Maria Knutson Wedel, Chalmers]

Educational development strategies


In disciplinary courses

- Improving the quality of understanding
- Knowledge prepared for use: seeing the knowledge through the lense of problems
- Ability to communicate and collaborate
- Interconnecting the disciplines

In problem/practice-based courses

- Adding problem/practice-based learning experiences
  - Early engineering experience
  - A sequence of Design-Implement Experiences
- Improving reflection and learning
- Improving cost-effectiveness of teaching

Design-Implement Experiences

student teams design and implement actual products, processes, or systems

- Projects take different forms in various engineering fields
- The essential aim is to learn through near-authentic engineering tasks, working in modes resembling professional practice

CDIO Standard 5 – Design-Implement Experiences
A curriculum that includes two or more design-implement experiences, including one at a basic level and one at an advanced level.

- Progression in several dimensions
  - engineering knowledge (breadth and depth)
  - size of student teams
  - length of project
  - increasingly complex and open-ended problems
  - tensions, contextual factors
  - student and facilitator roles

Learning in Design-Implement Experiences

- *The purpose is not to build things, but to* ***learn*** *from building things*

- it is key that students bring their designs and solutions to an **operationally testable state**.
- To turn practical experiences into learning, students are continuously guided through **reflection and feedback exercises** supporting them to evaluate their work and identify potential improvement of results and processes.
- **Assessment and grading** should reflect the quality of attained **learning outcomes**, rather than the product performance in itself

The educational development process is the working definition of CDIO:

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Context:
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Faculty development
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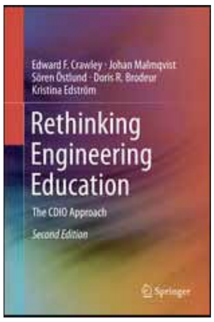
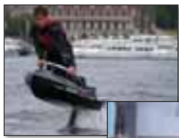


Crawley, et al (2007, 2014) *Rethinking Engineering Education: The CDIO Approach*, Springer.

CDIO integrated curriculum development - the process in a nutshell

- **Set program learning outcomes**
  in dialogue with stakeholders
- **Design an integrated curriculum**
  mapping out responsibilities to courses
  – negotiate intended learning outcomes
  (both knowledge and engineering skills)

- **Create integrated learning experiences**
  course development with constructive alignment
  - ✓ mutually supporting **subject courses**
  - ✓ applying **active learning methods**
  - ✓ an **introductory course**
  - ✓ a sequence of **design-implement experiences**



- **Faculty development**
  - ✓ Engineering skills
  - ✓ Skills in teaching, learning and assessment
- **Evaluation** and continuous **improvement**

What is CDIO?

3. A <u>community</u> to learn together and to share experience

The CDIO Initiative

cdio
CONCEIVE DESIGN IMPLEMENT OPERATE

CDIO as a community – the CDIO Initiative

- **The CDIO Initiative** started in 2000 as a project:
  Partners: MIT, KTH, Chalmers, Linköping University
- Soon other institutions expressed an interest in joining, today **more than 125 CDIO Collaborators** worldwide

The international CDIO community

North America
- Arizona State University
- California State University, Northridge
- Daniel Webster College
- Duke University
- École Polytechnique de Montréal
- Embry-Riddle Aeronautical University
- LASPAU
- Massachusetts Institute of Technology
- Naval Postgraduate School (U.S.)
- Pennsylvania State University
- Queen's University (Canada)
- Sheridan College
- Stanford University
- United States Naval Academy
- University of Arkansas
- University of Calgary
- University of Colorado
- University of Manitoba
- University of Michigan
- University of Notre Dame

Latin America
- Pontificia Universidad Javeriana
- School of Engineering of Antioquia (EIA)
- UNITEC Laureate International Universities
- Universidad Católica de la Santísima Concepción
- Universidad de Chile
- Universidad de Santiago de Chile
- Universidad del Quindio
- Universidad del Quindío
- Universidad ICESI, Cali
- Universidad Nacional de Colombia, Bogota

Australia
- AAEE
- Chisholm Institute
- Curtin University
- Queensland University of Technology
- RMIT
- University of Auckland
- University of Sydney
- University of the Sunshine Coast

Asia:
- Beijing Institute of Petrochemical Technology
- Beijing Jiaotong University
- Chengdu University of Information Technology
- Chulalongkorn University, Thailand
- Dalat University, Vietnam
- Dalian Neusoft University of Information
- Duy Tan University
- Feng Chia University, Taiwan
- FPT University, Vietnam
- Inje University, Korea
- Kanazawa Institute of Technology
- Kanazawa Technical College
- Mongolian University of Science and Technology
- Nanyang Polytechnic
- Politeknik Ungku Omar, Malaysia
- Rajamangala University of Technology Thanyaburi (RMUTT)
- Shantou University
- Singapore Polytechnic
- Suzhou Industrial Park Institute of Vocational Technology
- Taylor's University, School of Engineering
- Thu Dau Mot University
- Tsinghua University
- Universiti Teknologi MARA (UiTM)
- Vietnam National University
- Yanshan University

Africa
- University of Pretoria
- ESPRIT, Tunisia

UK-Ireland:
- Aston University
- Lancaster University
- Queen's University (Belfast)
- South Eastern Regional College (SERC)
- Trinity College Dublin
- University of Bristol
- University of Chichester
- University of Leeds
- University of Leicester
- University of Limerick
- University of Liverpool
- University of Strathclyde

Europe:
- AFEKA Tel Aviv Academic College of Engineering
- Astrakhan State University
- Bauman Moscow State Technical University
- Cherepovets State University
- Delft University of Technology
- Don State Technical University
- Ernst-Abbe-University of Applied Sciences Jena
- Gdansk University of Technology
- Ghent University
- Group T - International University College Leuven
- Hague University of Applied Sciences
- Helsinki Metropolia University of Applied Sciences
- Hochschule Wismar
- Instituto Superior de Engenharia do Porto
- Israel Institute for Empowering Ingenuity
- Kazan Federal University
- Lahti University of Applied Sciences
- Lapland University of Applied Sciences
- Moscow Aviation Institute
- Moscow Institute of Physics and Technology
- National Research Nuclear University
- Novia University of Applied Sciences
- Politecnico di Milano
- Reykjavik University
- RWTH Aachen
- Saint Petersburg State University of Aerospace Instrumentation
- Savonia University of Applied Sciences
- Technical University of Madrid
- Seinäjoki University of Applied Sciences
- Siberian Federal University
- Skolkovo Institute for Science and Technology
- Telecom Bretagne
- Tomsk Polytechnic University
- Tomsk State University of Control Systems and Radioelectronics (TUSUR)
- Turku University of Applied Sciences
- Universitat Politècnica de Catalunya
- University of Turku
- TU Madrid
- Ural Federal University
- Vilniaus Kolegija/University of Applied Sciences
- Østfold University College
- Chalmers
- KTH
- Linköping University
- Jönköping University
- Umeå University
- Linnéaus University
- University of Skövde
- Kristianstad University
- Blekinge Institute of Technology
- Luleå University of Technology
- Högskolan Väst

Annual International CDIO Conference

2005 Queen's University, Kingston, Canada

2006 Linköping University, Linköping, Sweden

2007 Hogeschool Gent, Gent, Belgium

2008 MIT, Cambridge MA, USA

2009 Singapore Polytechnic, Singapore

2010 École Polytéchnique, Montreal, Canada

2011 Denmark Technical University, Copenhagen, Denmark

2012 Queensland University of Technology, Brisbane, Australia

2013 Harvard/MIT, Cambridge MA, USA

2014 UPC, Barcelona, Spain

2015 CUIT, Chengdu, China

2016 Turku UAS, Turku, Finland

2017 University of Calgary, Canada

www.cdio.org

Next:

- **European CDIO Regional meeting**
  January 2017, Skolkovo, Moscow, Russia
- **14th International CDIO Conference**
  June 2018, Kanazawa, Japan
- **15th International CDIO Conference**
  June 2019, Aarhus, Denmark

How to become a CDIO Collaborator

1. Express an interest (answer a few questions)
   - Why does your university want to join the CDIO initiative?
   - Which of your programs do you plan to initially apply CDIO? How do you expect CDIO to influence these programs?
   - What goals do you hope to achieve?
   - What are your plans for participating with the other CDIO collaborating schools?
   - What experience do you have in engineering educational reform at your university, which might contribute to the effort and form a foundation for the work as a collaborator?
   - What level of commitment and support do you have from your university's Dean and Central Leadership?
   - Who will be the key two to five participants in your effort?
2. Make introductions at a CDIO meeting
3. The CDIO Council will grant collaborator status

- Contact the leader of your region, to get started.
  (see www.cdio.org)

What is CDIO?

1. **An idea** of what engineering students should learn:
   "Engineers who can engineer"
2. **A methodology** for engineering education reform:
   The twelve **CDIO Standards**
3. **A community** to learn and share the experience:
   The **CDIO Initiative**

cdio

CONCEIVE DESIGN IMPLEMENT OPERATE

KTH ROYAL INSTITUTE
OF TECHNOLOGY

Program Development and Management

Hans Havtun

Program Director **Energy and Environment**
hans.havtun@energy.kth.se

Agenda

- The Energy and Environment program
- The organization of the program
- The program perspective
- How students influence the program

My background

- MSc Mechanical Engineering, KTH, 1995
- PhD Energy Technology, KTH, 2001 (Cooling of Electronics)
- Associate Professor in Energy Technology
- Teaching at KTH since 1995, mainly
  Thermodynamics, Energy Utilisation, and Cooling of Electronics
- Director of Studies, Dept Energy Technology, KTH, 2001-2009, 2011
- Pedagogical Developer 2014-2016
- Program Director Energy and Environment, 2016-
- Member of the Pedagogical Council of KTH, 2017-

The Energy and Environment program

- History
- Program focus and Program outcomes
- Courses at the BSc level
- MSc programs available for the students

History: Energy and Environment

- One of KTH’s newest 5-year engineering program (3-year BSc, and 2-year MSc)
- Decision taken to start program in 2009
- Program developed during 2009-2010 (however, a lot of work had been done during 2008)
- The first students were admitted autumn 2010
- In 2015 the first students were graduated
- On October 9, 2017, the 100th student graduated from the program.

Program focus – Sustainable development

- Sustainable development is by definition a cross-diciplinary subject area
- The program attracts students with different interests and backgrounds
- It offers a number of MSc programs from different schools at KTH
- Courses are offered by five different schools

Engineering degrees awarded

Bologna convention

Academic degrees

BSc — 3 years

MSc — 2 years

Swedish convention

Professional degree

MSc in Engineering — 5 years

Even though the courses may be identical,
the program outcomes differs slightly

Program outcomes (5 year program)

In addition to the objectives specified in the Swedish Higher Education Ordinance, a graduate Master of Science in Engineering from Energy and Environment at KTH shall …

Program outcomes

Knowledge and understanding

- have basic knowledge of all aspects of the energy system in a broad sense, which includes the technologies and subsystems that are found in all stages from energy source to the energy's end use, and be able to understand these as socio-technical systems consisting of both technical components and the actors that develop, manages and use the system

- have good knowledge of the processes of modelling, simulation and validation of energy and environmental systems using modern engineering tools

- possess good knowledge of conditions relating to innovation, corporate enterprises and business in terms of the planning, strategies and objectives of businesses within the energy and environment sector

Program outcomes

Skills and abilities

- be able to describe sustainable development and relevant environmental problems at a foundational level, i.e., visions, concepts, definitions, and be able to provide a description of the current global situation
- be able to, in a professional way, express themselves and communicate thoughts, ideas, visions and results to those in their professional proximity and the surrounding community
- be able to critically analyse the historical and future importance of the energy and environment sector for global and local societal development and its relation to ecological systems
- be able to compare and discuss different perspectives on issues of importance to sustainable development

Program outcomes

Ability to make judgments and adopt a standpoint

- have a holistic view of sustainable development with systems and life-cycle thinking for products and services and for technical systems, based on an interdisciplinary approach and based on different actor perspectives
- have the ability to assess ethical issues and conflicts of objectives relating to sustainable development, and demonstrate a deep knowledge of the engineer's role and responsibilities in society, especially regarding social and economic aspects and environmental/ecological aspects
- have the skills to challenge, develop and problematise prevailing habits, thought patterns, technical and economic systems, and cultural and societal values.

Courses at the BSc level

- At the BSc level, the program has 19 compulsory courses,
- 3-4 conditionally elective prerequisite courses, and
- 1 freely elective course

- The conditionally elective prerequisite courses are chosen based on the MSc program the student want to pursue

Year 1

P1	P2	P3	P4
Energy, climate, and environment	Ecology and Environmental Effects	Mechanics	Basic Chemistry
Algebra and Geometry	Calculus in One Variable	Calculus in Several Variables	Electromagnetism and Waves

Year 2

<table>
<tr><th>P1</th><th>P2</th><th>P3</th><th>P4</th></tr>
<tr><td colspan="2">Numerical Methods and Basic Programming</td><td>Material and Energy Balances</td><td>Environmental Systems Analysis</td></tr>
<tr><td>Differential Equations</td><td>Probability Theory and Statistics</td><td rowspan="2">Electrical Circuit Analysis</td><td rowspan="2">Energy Systems</td></tr>
<tr><td colspan="2">Thermodynamics</td></tr>
</table>

The focus of this year is modeling of components and systems

Year 3

P1	P2	P3	P4
	Energy Systems in Society	Environmental Economics	
		Bachelor Thesis	

The empty spaces are filled with conditionally elective prerequisite courses decreed by the MSc programs, and one freely elective course.

The focus of this year is communication.

Year 3 – Electric Power Systems

P1	P2	P3	P4
Vector Analysis	Energy Systems in Society	Environmental Economics	Language Course
Electromagnetic Theory, introduction course		Bachelor Thesis	
Automatic Control	Electric Power Systems		

MSc programs available

At KTH

- Electric Power Engineering
- Sustainable Energy Engineering
- Sustainable Urban Planning and Design
- Chemical Engineering
- Environmental Engineering and Sustainable Infrastructure
- Sustainable Technology
- Industrial Engineering and Sustainability

Students are guaranteed admission

One year at a foreign university*

- Environomical Pathways for Sustainable Energy Systems
- Renewable Energy
- Smart Electrical Networks and Systems
- Energy for Smart Cities

Students are selected in competition with students world wide

* Through EIT Innoenergy

Positions of graduated students

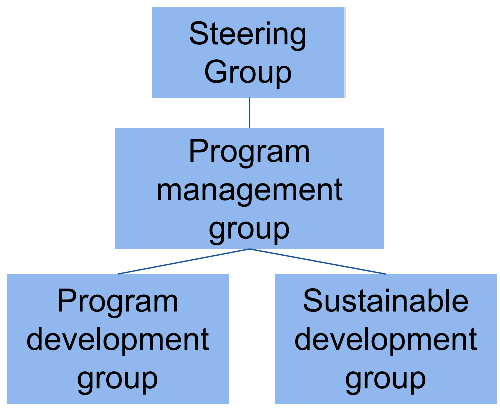
Energy consultant, private sector
Energy and climate advisor, municipality
Project engineer, government office
Building project manager, private sector
Land management engineer, private sector
Surface water and sewage water project manager, private sector
Electric supply network investigations manager, private sector
Project manager, Energy in buildings, private sector
Technical project manager, private sector
Waste manager, municipality

Agenda

- The Energy and Environment program
- **The organization of the program**
- The program perspective
- How students influence the program

The organization of the program

- Steering group (Director of undergraduate education of schools)
- Program management group
- Program development group
- Sustainable development group



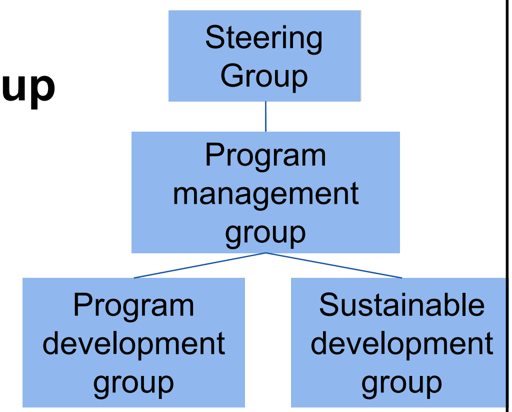
Steering group

As the program is multi-disciplinary, a steering group consisting of representatives from the four schools at KTH with interest in the program:

- Industrial Engineering and Management
- Architecture and Built Environment
- Electrical Engineering
- Chemical Engineering

Decides on economical issues and strategical changes in the program

Program management group



Program director
Program secretary
Student counsellor
International coordinator

- Daily program management, handle exchange students
- ”Planning” courses that are in the program
- Responsible for fulfillment of program outcomes
- Responsible for approving diploma applications

Program development group

Consists of:

Program management group

Master program directors

Teachers representing courses with special roles in the program

Student representatives

- Suggest/Investigate changes to the program => Steering group
- Meets 3-4 times a year

Sustainable development group

Consists of:

Vice program director (responsible for sustainable development)

Representatives for each master program

Student representatives

- Suggest changes in courses/program to enhance sustainable development aspects
- Ensure that sustainable development outcomes in the program are met

Agenda

- The Energy and Environment program
- The organization of the program
- **The program perspective**
- How students influence the program

The program perspective

A number of Courses builds the Program
How can the Program director influence courses?
A course in a program may be offered:
- by a different school!
- to several programs with different program outcomes!

Quite hard to…
- influence courses as a program director
- assess fulfillment of program outcomes

How to assess fulfillment of program outcomes

- Each program outcome is breaken down into smaller sub-outcomes
- All courses are investigated to see which program outcomes that are fulfilled and to what degree (partial, full)
- This is done by looking at the assessment of course modules and the course learning outcomes linked to them
- Finally, a table of all the program outcomes, sub-outcomes, courses, and course modules that fulfills program outcomes can be compiled

Example

Program outcome:
…have basic knowledge of all aspects of the energy system in a broad sense, which includes the technologies and subsystems that are found in all stages from energy source to the energy's end use, and be able to understand these as socio-technical systems consisting of both technical components and the actors that develop, manages and use the system.

Example

Discerning sub-outcomes:

- …
- … technologies and subsystems that are found in all stages from energy source to the energy's end use …
- ….

Example

Program sub-outcomes:

have basic knowledge of… technologies and subsystems …

- Energy sources
- Energy conversion
- Energy end-use

Example

Program sub-outcomes:
have basic knowledge of… technologies and subsystems …

- Energy sources
- **Energy conversion**
- Energy end-use

Example

Course: Thermodynamics
Course Module(s): Examination, Assignments
Course outcomes: After the course, the student should be able to:

- formulate, model, and solve problems involving systems and devices having various forms of energy exchange and energy conversion.
- model systems, and to be able to identify sub-systems and components in engineering systems.
- present stringent and understandable solutions to problems in the field of thermodynamics.

Example

Course: Thermodynamics
Course Module(s): Examination, Assignments
Course learning outcomes: After the course, the student should be able to:

- formulate, model, and solve problems involving systems and devices having **various forms of** energy exchange and **energy conversion**.
- model systems, and to be able to identify sub-systems and components in engineering systems.
- present stringent and understandable solutions to problems in the field of thermodynamics.

Example

- Apparently, the *Thermodynamics course* contributes to the program outcomes.
- To what degree? Is the program outcome fully met?
- As it does not cover **all** types of energy conversion, the program outcome is partially fulfilled.

Program outcome	Sub-outcome	Course	Assessment module	Degree
1	Energy conversion	Thermo-dynamics	Examination, Assignments	Partial
1	Energy conversion	Energy Systems	Project	Partial

Agenda

- The Energy and Environment program
- The organization of the program
- The program perspective
- **How students influence the program**

How students influence the program

Students play a very important role in program development

- They are represented in (almost) every deciding body at KTH
- They provide feedback to courses, and the program
- They are represented by the student union
- They arrange their own program evaluation day

How students influence the program

The student union appoint representatives sitting in the *KTH board*.

The students in the Energy and Environment program have their own chapter of the student union.

The chapter has a *studies committee* that monitor the quality of the program. The committee has one chairperson, and a vice chairperson. Each program also has a program responsible student.

Each class has student representatives.

These representatives attend the meetings arranged by the program: Program conference, Program development group, Sustainable development group, Schedule-planning meeting, Semester start-up meeting, ”Link meetings”

Support activities for the program

Program Director’s network: All program directors at KTH meet once a month (arranged by KTH centrally)

Program conference: Held every year where all teachers in the program and student representatives meet to discuss program development.

Schedule-planning meetings: teachers having parallel courses meet *prior to scheduling* their courses to avoid clashes of exams, deadlines, etc.

Semester start-up meetings: teachers having parallel courses meet *a week before the semester starts* to inform each other about deadlines in their respective courses.

”Link meetings”: Teachers having parallel courses and student representatives meet *twice during each semester* to discuss progress of the semester

Program development + Sustainable development group meetings

Ongoing program work (2017)

- Each MSc program should issue a document stating that the Energy and Environment program outcomes are met
  - all specializations of all MSc programs (difficult as the MSc program may also be connected to other engineering programs).
  - progression of skills and abilities
  - sustainable development outcomes
- Establishing the Sustainable Development Group
- Establishing an Industrial Reference Group

Today's theme:

Integration of Sustainable Development

Anders Rosén & Emma Strömberg

Enhancing Engineering Education
KTH Workshop Oct 2017

Who are we?

Dr. Emma Strömberg

- Associate professor in Polymeric materials at Fiber and Polymer Technology.
- Teaching Sustainable Development and Polymeric Science.
- Former program director for the Master program: Materials and Sensor Engineering for Environmental Sustainability.
- Working with strategic pedagogical development including integration of sustainable development in educational programs.

Dr. Anders Rosén

- Associate professor in Naval Architecture.
- Teaching Ship Design & High-speed Craft.
- Program director for the Master program: Naval Architecture.
- Working with pedagogical development and CDIO.

Today's agenda

- What is sustainable development?
- How is the state of the world?
- What can we do about it?

What is sustainable development?

What is Sustainable Development?

Please turn to your neighbour and discuss for 5 minutes :

- What is it that should be sustained ?
- What is it that should be developed ?

What is Sustainable Development?

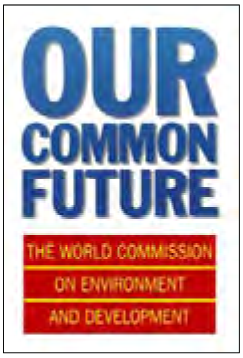
Sustainable development is a vague and highly complex concept that is difficult to understand and subject to endless definition and re-definition…

Just like other important concepts, such as democracy, welfare and justice, sustainable development is not subject to an analytically precise definition…

(Cruickshank & Fenner 2012)

This however doesn't make it less important!

The first ”definition” of Sustainable Development



…also known as the Brundtland Report,
by the United Nations World Commission on Environment and Development (WCED), 1987.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Contains two key concepts:
1. the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
2. the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

Sustainability principles according to The Natural Step

In a sustainable society, nature is not subject to systematically increasing:

1) concentrations of substances extracted from the earth's crust (e.g. heavy metals and CO2 from fossil fuels);

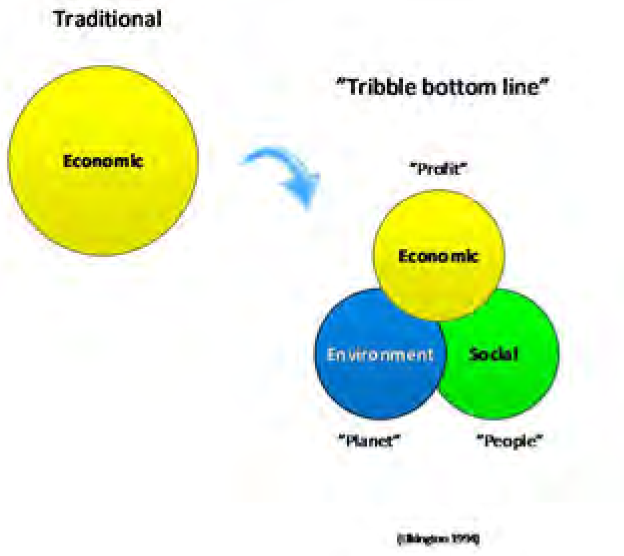
2) concentrations of substances produced by society (e.g. antibiotics, plastics, dioxins)

3) degradation by physical means (e.g. deforestation, destroying habitat, overfishing, draining groundwater tables);

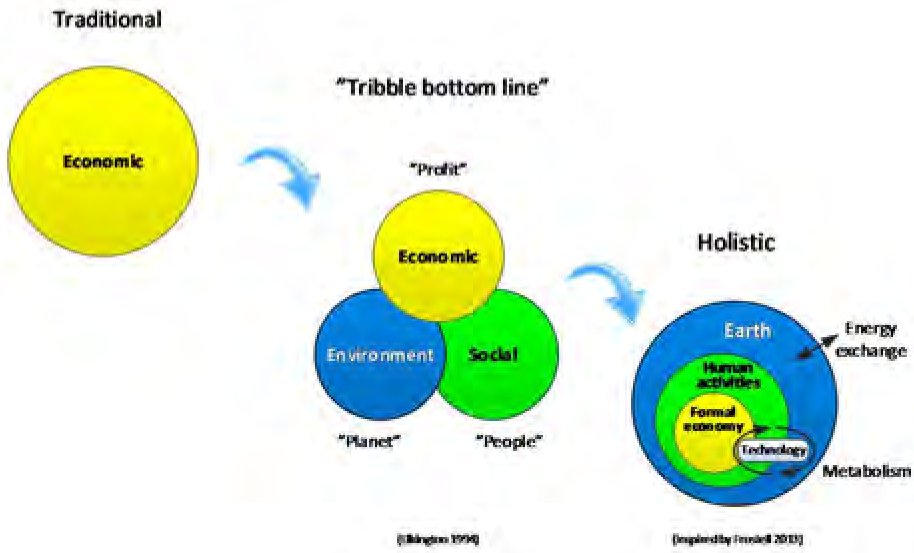
4) And in that society, there are no structural obstacles to people’s health, influence, competence, impartiality and meaning (e.g. unsafe working conditions, not enough pay to live on).

http://www.thenaturalstep.org/our-approach/

Three dimesions of Sustainable Development



Three dimesions of Sustainable Development



Three dimesions of Sustainable Development

…reflected in the degree qualifiers in the Swedish Higher Education Ordinance for the Master of Science in Engineering Degree:

9. demonstrate an ability to develop and design products, processes and systems taking into account people's situations and needs and the **society's objectives for economically, socially and ecologically sustainable development**;

14. demonstrate insight into the potential and limitations of technology and science, its role in society and people's responsibility for how it is used, **including social and economic aspects, as well as environmental and work environment aspects**;

How is the state of the world?

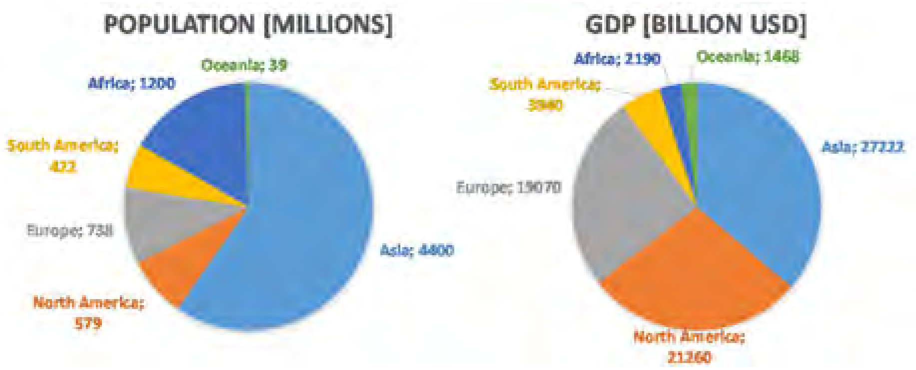
How is the state of the world?

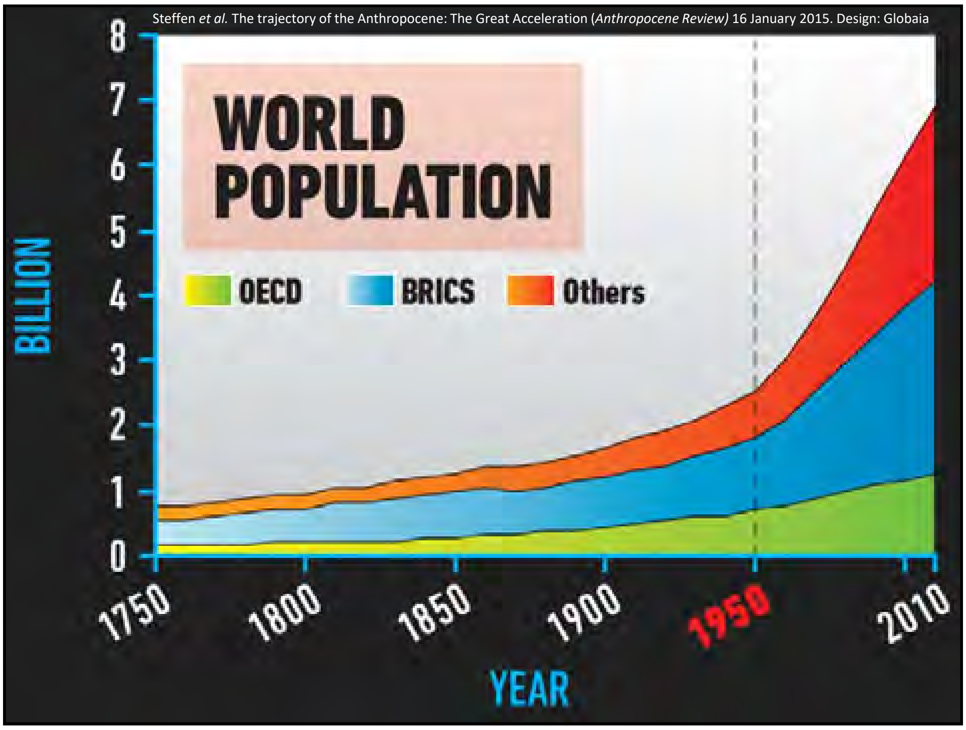
Workshop A

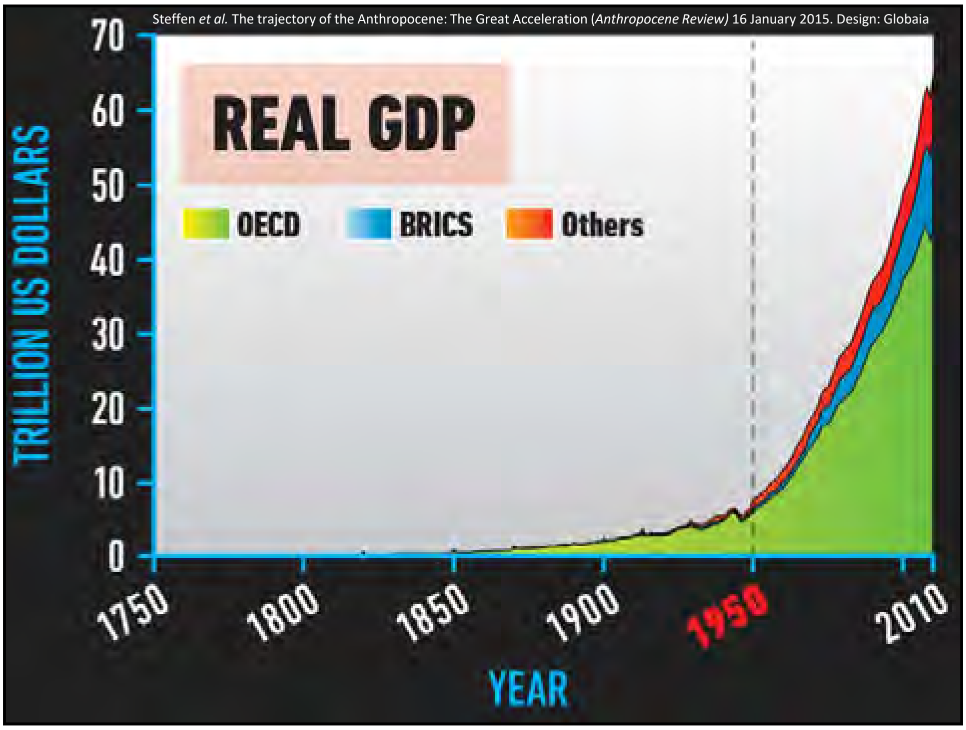
“Fika” challenge…

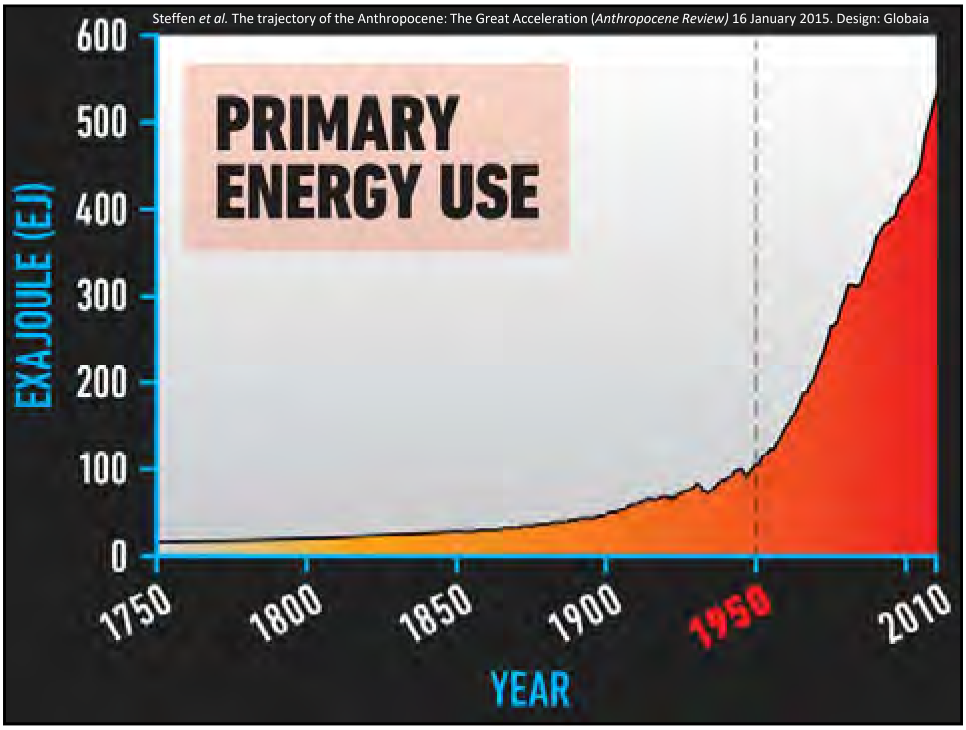
How is the state of the world?

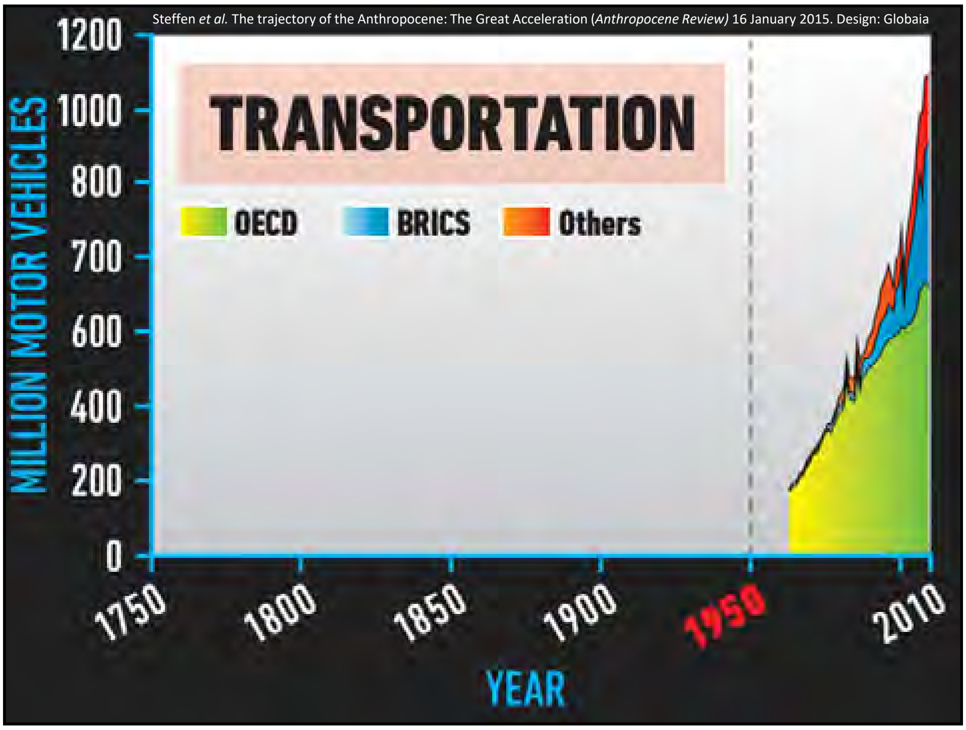
”Fika” challenge…

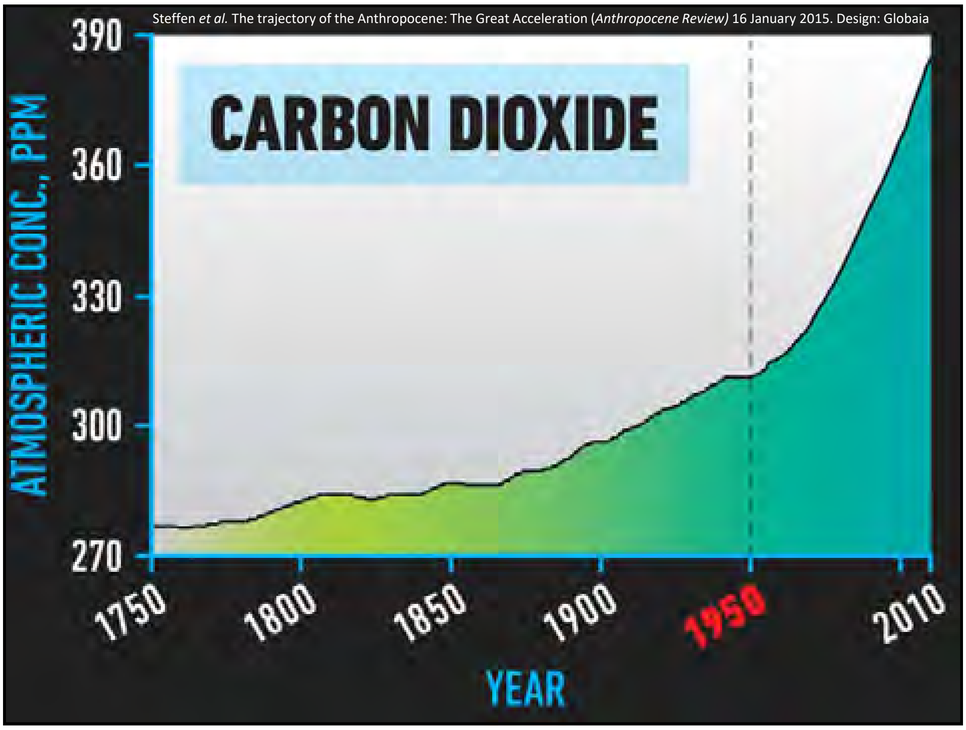


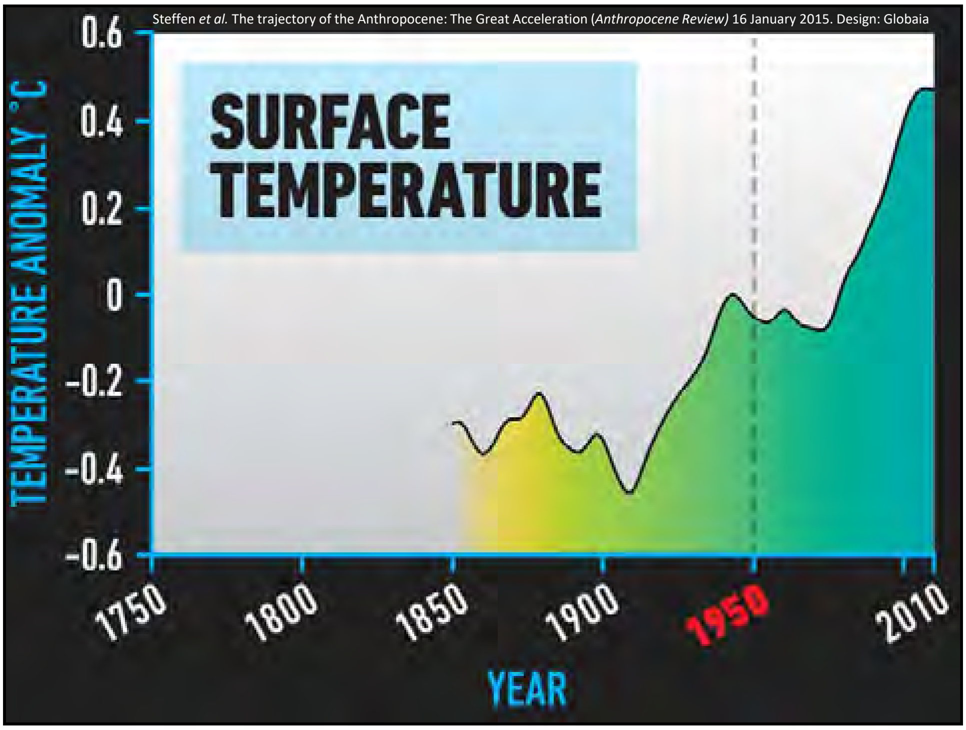

Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
WORLD POPULATION
OECD
BRICS
Others
BILLION
8
7
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2010
YEAR

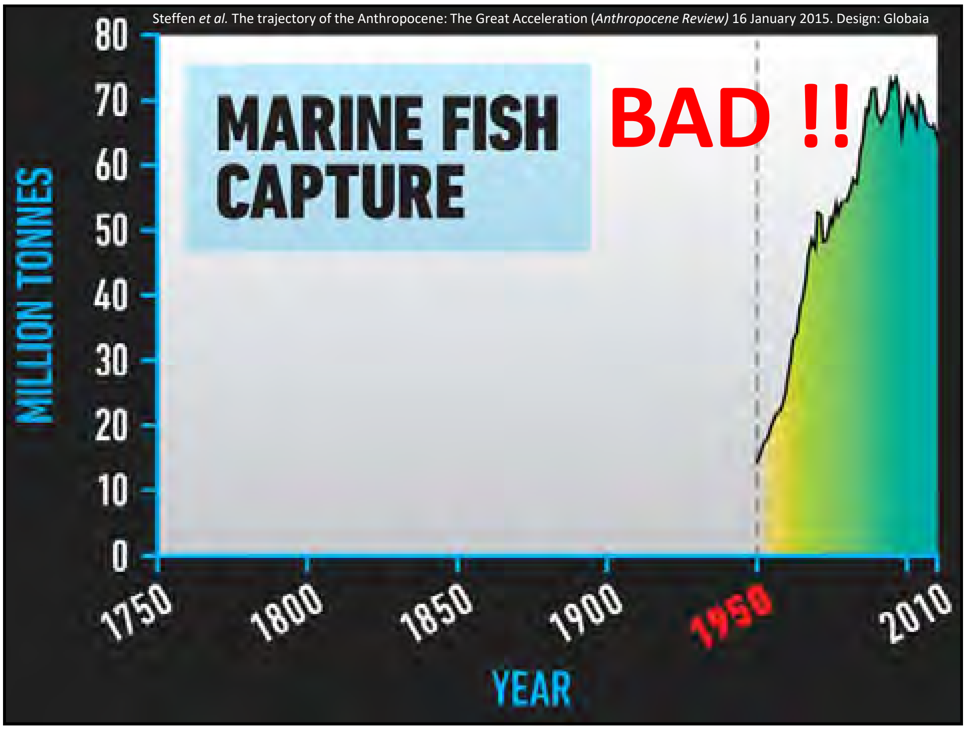

Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
REAL GDP
OECD
BRICS
Others
TRILLION US DOLLARS
70
60
50
40
30
20
10
0
1750
1800
1850
1900
1950
2010
YEAR


Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
PRIMARY ENERGY USE
EXAJOULE (EJ)
600
500
400
300
200
100
0
1750
1800
1850
1900
1950
2010
YEAR


Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
TRANSPORTATION
OECD
BRICS
Others
MILLION MOTOR VEHICLES
1200
1000
800
700
600
400
200
0
1750
1800
1850
1900
1950
2010
YEAR


Steffen *et al.* The trajectory of the Anthropocene: The Great Acceleration (*Anthropocene Review)* 16 January 2015. Design: Globaia
CARBON DIOXIDE
ATMOSPHERIC CONC., PPM
390
360
330
300
270
1750
1800
1850
1900
1950
2010
YEAR


Steffen *et al.* The trajectory of the Anthropocene: The Great Acceleration (*Anthropocene Review)* 16 January 2015. Design: Globaia
SURFACE TEMPERATURE
TEMPERATURE ANOMALY °C
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1750
1800
1850
1900
1950
2010
YEAR


Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
MARINE FISH CAPTURE
BAD !!
MILLION TONNES
80
70
60
50
40
30
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10
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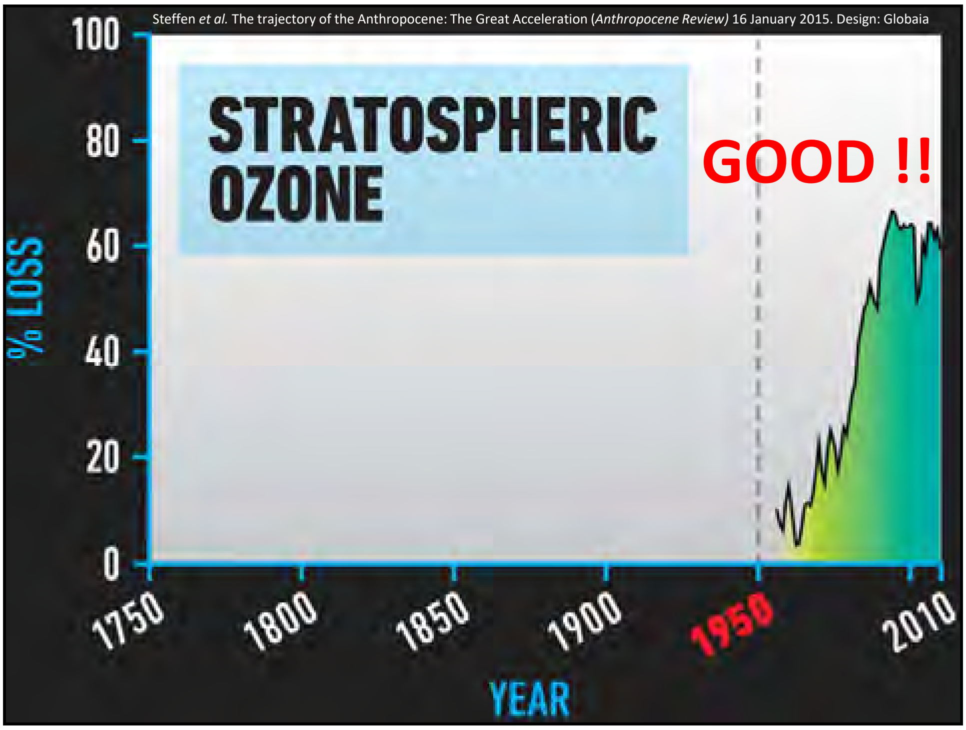
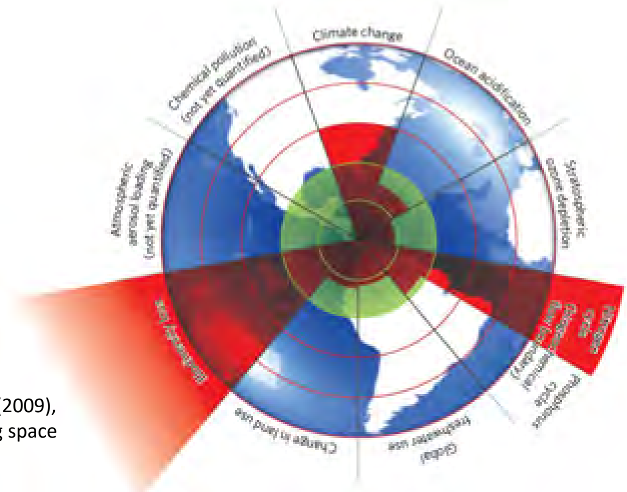
1750
1800
1850
1900
1950
2010
YEAR


Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
STRATOSPHERIC OZONE
GOOD !!
% LOSS
100
80
60
40
20
0
1750
1800
1850
1900
1950
2010
YEAR

How is the state of the world?

Research based status descriptions



Rockström et al (2009), ”A safe operating space for humanity”, identifying and quantifying planetary boundaries.

How is the state of the world?

Research based status descriptions

http://www.gapminder.org/answers/how-did-the-world-population-change/

Hans Rosling got the KTH Great Prize in 2010.

Now let's do some workshopping!

How is the state of the world?

Workshop groups

Grupp 1

Ahmed Elsabbagh	Ain Sham University, Egypt
Chinandu Mwendapole	Botho University, Botswana
Eunice Ja Young Kim	Korea University, South Korea
Andrei Popa	SUCahul, Moldova
Rodica Bugai	SUMPh, Moldova

Grupp 2

Mohamed Abdelaziz	Ain Sham University, Egypt
Suresh Shanmugasundaram	Botho University, Botswana
Liudmila Rosca-Sadruschi	SUCahul, Moldova
Mariana Spatari	USARB, Moldova
Liliana Turcan	USM, Moldova

Grupp 3

Mohamed Sheirah	Ain Sham University, Egypt
Eunju Jung	Korea University, South Korea
Natalia Gasitoi	USARB, Moldova
Natalia Zamfir	USM, Moldova
Dinu Turcanu	UTM, Moldova

Grupp 4

Tamer Elnady	Ain Sham University, Egypt
Venkataraman Vishwanathan	Botho University, Botswana
Victoria Rotaru	SUMPh, Moldova
Valentina Pritcan	USARB, Moldova
Otilia Dandara	USM, Moldova
Larisa Bugaian	UTM, Moldova

How is the state of the world?

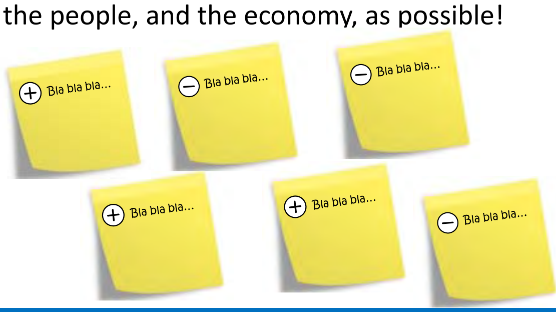
Workshop B / Part 1

- Which are the potentially good and bad influences from [industry sector] on the environment, people, and economy?
- Decide in the group on a suiting [industry sector] to workshop on.
- Declare after 5 minutes.

How is the state of the world?

Workshop B / Part 2

- Which are the potentially good and bad influences from [industry sector] on the environment, people, and economy?
- Brainstorm in your groups! Try to formulate as many good ⊕ and bad ⊖ influences (direct and/or indirect) on the environment, the people, and the economy, as possible!



Brain storming ”rules”:

- Go for quantity. Try to get 100 ideas!
- Encourage wild ideas. There are no right or wrong ideas.
- Don´t critique or debate ideas.
- Try building on each others ideas.

Recalling today's agenda…

- What is sustainable development?
- How is the state of the world?
- What can we do about it?

What can we do about it?

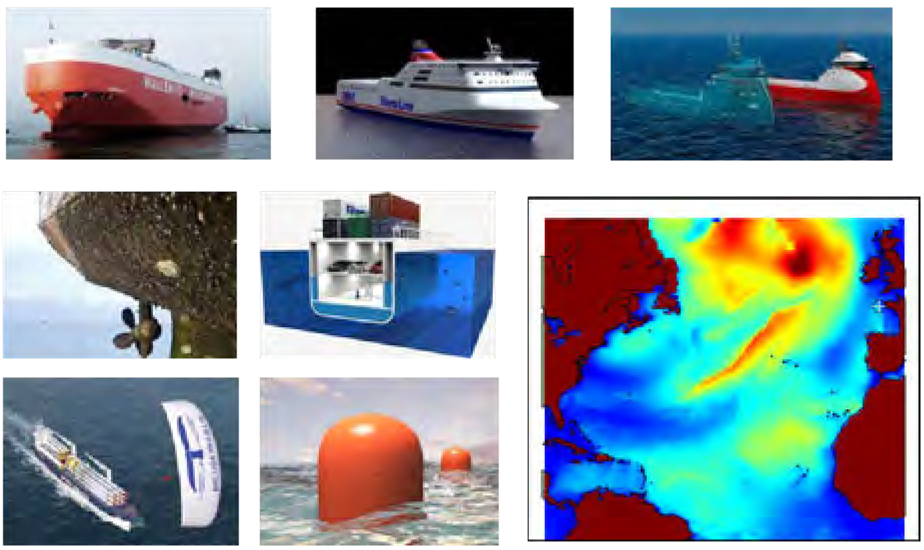
What can we do about it?

Technical development - Examples

2017-10-17 KTH Centre for Naval Architecture 31

What can we do about it?

Technical development - Examples



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What can we do about it?

Will
technical development
solve everything ?

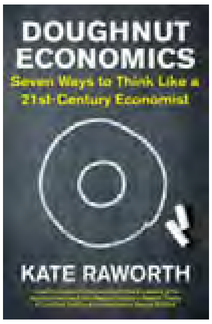
What can we do about it?

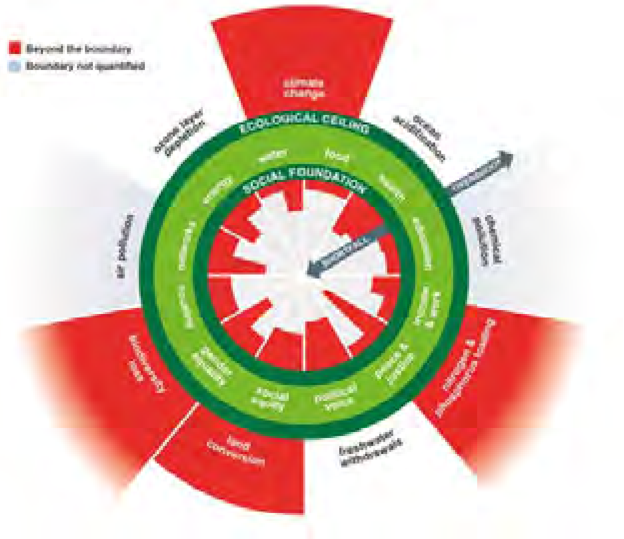
Changing lifestyles




What can we do about it?

New economic principles





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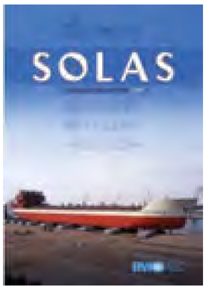
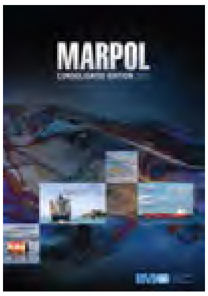
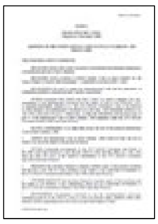
What can we do about it?

Policies, agreements, regulations







International, eg
IMO 2008 Intact Stability Code

International, eg
Classification Rules

National, eg
Transportstyrelsens
författningssamling

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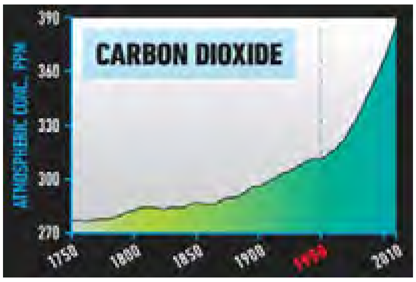
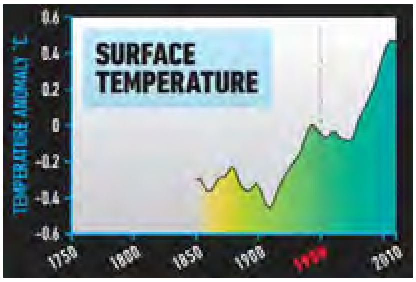
What can we do about it?

Policies, agreements, regulations





What can we do about it?

Policies, agreements, regulations

What can we do about it?

Policies, agreements, regulations

http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

http://www.undp.org/content/undp/en/home/librarypage/corporate/sustainable-development-goals-booklet.html

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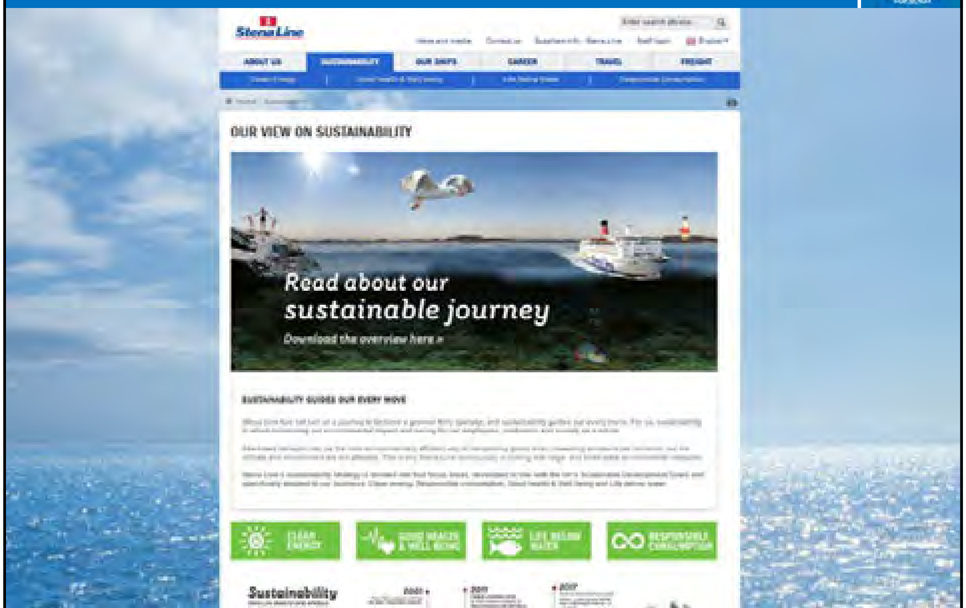
What can we do about it?

Policies, agreements, regulations



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Let's continue workshopping!

Workshop B / Part 3

- Which are the potentially good and bad influences from [industry sector] on the environment, people, and economy?
- Brainstorm in your groups! Try to formulate as many good ⊕ and bad ⊖ influences (direct and/or indirect) on the environment, the people, and the economy, as possible!
- Now try to categorize your goods and bads in relation to the Sustainable Development Goals. Add more if you can.
- Present your results on a poster.

Recalling today's agenda…

- What is sustainable development?
- How is the state of the world?
- What can we do about it?
  - Technical development.
  - New economic principles.
  - Policies, agreements, regulations.
  - What is KTH doing about it?
  - What could you do about it in your educations?

Now time for lunch!

Let's continue at 13…

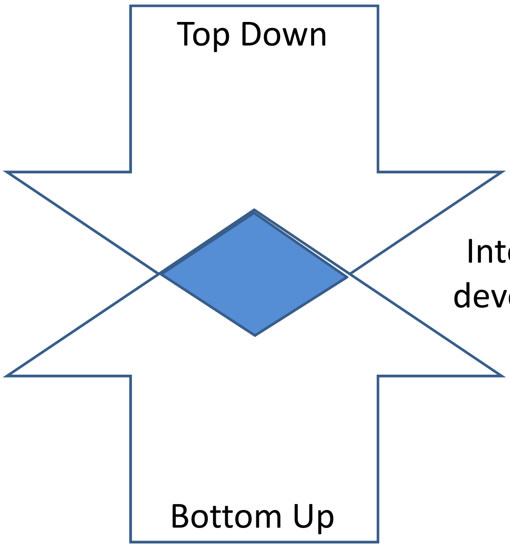
What is KTH doing about it?

Emma
talks about KTH…

Anders
introduces SDII…

What can we do about it?

Top Down vs Bottom Up



Integration of sustainable development in educations

What can we do about it?

Integration of Sustainable Development

How coud we teachers
talk about and collaborate on
integration of sustainable
development in our teaching?

What can we do about it?

Sustainable Development Integration Indicators

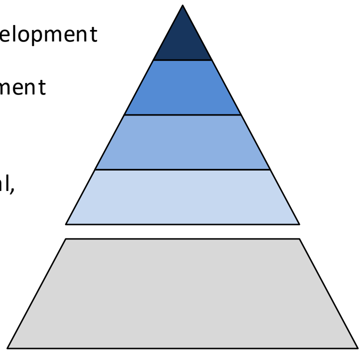
Level 4 : Specific skills for Sustainable Development

Level 3 : Literacy for Sustainable Development

Level 2 : Engineering applications

Level 1 : Exposure to environmental, social, and economic aspects

Core disciplinary knowledge



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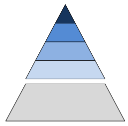
Now let’s do some more workshopping!

What can we do about it?

Workshop C / Part 1 – *Status*

1. Form groups of 4-5 members.
2. Shortly present the course you've chosen to bring to the workshop to eachother.
3. Discuss and try to categorized the levels (0-4) of integration of sustainable development in each of the presented courses.
4. Present your results on a poster.



Status

Course 1 name
L2: bla bla bla bla bla...
bla bla bla bla bla...
L1: bla bla bla...

Course 2 name
L0

Course 3 name
L3: bla bla bla bla bla...
bla bla bla...
L2: bla bla bla bla bla...
bla bla...
L1: bla bla bla bla bla...

Course 4 name
L0

Examples of integration of sustainable development in KTH courses

Emma talks
about her courses…

Anders talks
about his courses…

Example of integration of sustainable development in the course

SD2705 High-Speed Craft (6 ECTS)

…is there anything more environmentally hostile?

Sometimes they're needed!

Example of integration of sustainable development in the course

SD2705 High-Speed Craft (6 ECTS)

Learning Objectives:

The objective is that you after finishing the course shall be able to:

1. Demonstrate broad knowledge and understanding of the scientific basis and proven experience of high-speed craft design, deeper methodological knowledge, and insight into current research and development work.

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

a) formulate and analyse design requirements for high-speed craft;
b) identify and formulate the related design challenges;
c) create, analyse and evaluate different solutions for the hull structure and other parts of high-speed craft.

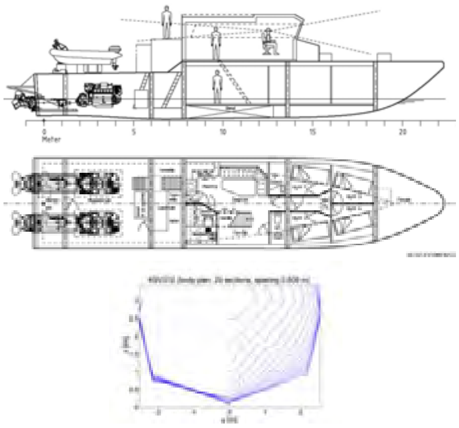
3. Demonstrate an ability to clearly present and discuss high-speed craft design aspects with reference to relevant theory and with use of appropriate terminology, orally as well as in writing in dialogue with different groups.

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

Example of integration of sustainable development in the course

SD2705 High-Speed Craft (6 ECTS)

- Design the propulsion system and the hull structure for a search and rescue craft, based on the following requirements:



Length	24	m
Beam	5	m
Deadrise at L/2	20	deg
Displacement, design	48	ton
Draft (at design displacement)	1.17	m
Service speed in calm water	30	kn
Range at top speed	300	Nm
Operational profile, 2000h/yr		
30kn	25	%
20 kn	50	%
10 kn	20	%
5 kn	5	%

DNV class notation +1A1 R1 HSLC Patrol E0

Example of integration of sustainable development in the course

SD2705 High-Speed Craft (6 ECTS)

Trough the course the students are challenged with considering conflicting requirements and discuss and decide on appropriate trade-offs:

- **Social** motivation **for** travelling at high speed:
  - In the first home assignment the students should read an article from the journal *Professional Boatbuilder* about a case study for a high-speed search and rescue boat (”*...most offshore boating accident deaths results from hypotherimia and not from drowning... make it clear that to be effective any search-and-rescue boat must be fast and ready to get under way quickly*”)
- **Social** motivation **against** travelling at high speed:
  - High speed in waves generate violent craft motions which are fatiguing for the crew an even might result in severe crew injuries
- **Economic** motivation **against** travelling at high speed:
  - High speed in waves generate large hydrodynamic loads which require a strong and heavy hull structure which in turn result in large material consumption, high building cost, large craft weight, large resistance through the water, high fuel consumtion, and high operational cost
- **Environmental** motivation **against** travelling at high speed:
  - ...high fuel consumption, large environmental impact.

Example of characterization & enhancement of the level of integration of sustainable development in an educational program

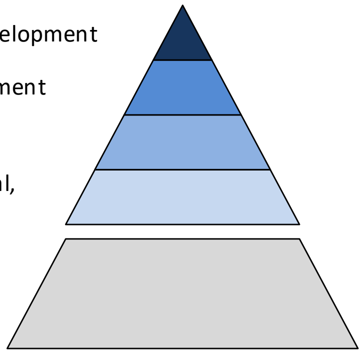
Level 4 : Specific skills for Sustainable Development

Level 3 : Literacy for Sustainable Development

Level 2 : Engineering applications

Level 1 : Exposure to environmental, social, and economic aspects

Core disciplinary knowledge



Rosén (2017)

Example of characterization & enhancement of the level of integration of sustainable development in an educational program

Example analysis: Level of integration of Sustainable Development in the KTH Naval Architecture Program

	Autumn term year 1	Spring term year 2	Autumn term year 2
Core Mandatory	SD2721 Ship Design (9 ECTS) SD2722 Marine structures (7.5 ECTS) SG2411 Lightweight Structures (8 ECTS)	SD2723 Marine hydromechanics (7.5 ECTS) SD2721 could have a key role introducing and establishing a baseline for SD which could then be built on in following courses. SD2722, SD2723, and SD2702 probably have potential for even higher level integration of SD.	AK2036 Theory of science (7.5 ECTS)
Core Elective		SG2702 Naval Design (20 ECTS) SD2705 considers trade-off between environmental, economic, and social aspects. SD2702 & SD2709 probably have potential for enhanced integration of SD.	SD2705 High-Speed Craft (6 ECTS) SD2709 Underwater technology (7.5 ECTS)
Track A Lightweight Structures	Track A: SD2414 could have a key role, considering environmental as well as social and economic aspects.	SD2414 Fibre Composites – materials & manufacturing (6 ECTS) SD2413 Fibre Composites – analys & design (6 ECTS)	SD2416 Structural Optimization & Sandwich Design (6 ECTS)
Track B Fluid Mechanics	SG2214 Fluid Mechanics (7.5 ECTS)	SG2212 Computational Fluid Mechanics (7.5 ECTS) SG2224 Applied Computational Fluid Mechanics (5 ECTS)	Track B: Very limited integration of SD. Some enhancement could be good. Track C: Integrates SD to the highest level. Students in other tracks should be encouraged to take one of AL2160 or AL2181 as elective.
Track C Management	EH2720 Management of Projects (7.5 ECTS)	AL2160 Environmental Managament (7.5 ECTS)	AL2181 Environmental System Analysis & Decision (7.5 ECTS)

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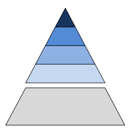
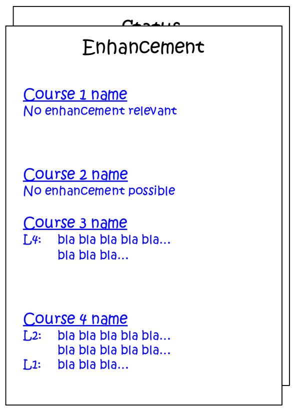
Let's continue workshopping!

What can we do about it?

Workshop C / Part 2 – Enhancement

1. Get back to your groups.
2. Discuss if and how the level of integration of sustainable development could be enhanced in each of the courses.
3. Present your results on a poster.

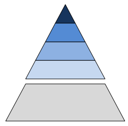




What can we do about it?

Workshop C / Part 3 – Global Goals

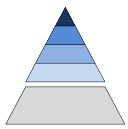
1. Get back to your groups.
2. Discuss if and how the courses relates to the Global Goals.
3. Present your results on a poster.

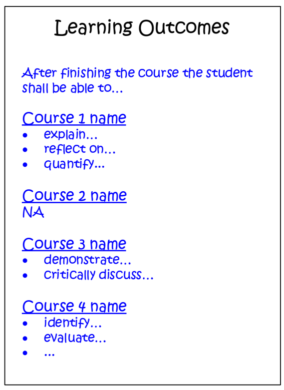


What can we do about it?

Workshop C / Part 4 – Learning outcomes

1. Get back to your groups.
2. Together sketch sustainable development related intended learning outcomes for your courses!
3. Present your results on a poster.

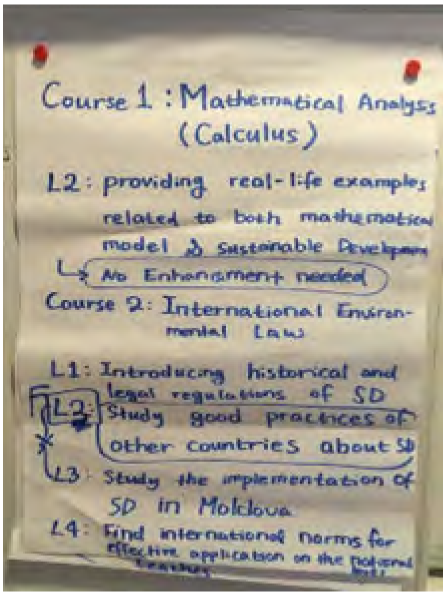


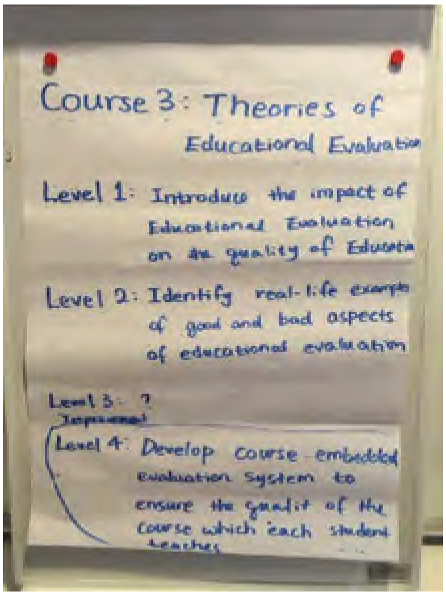


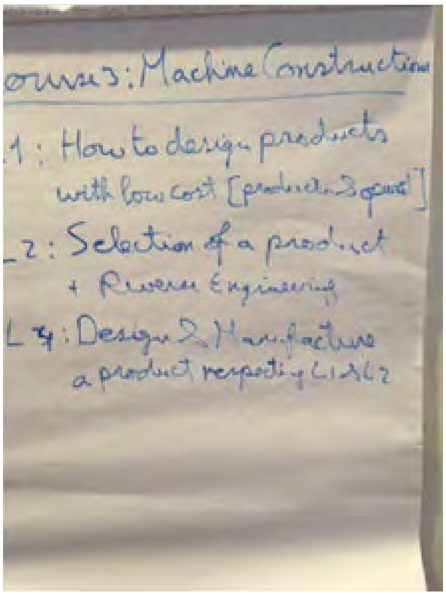

Cement Industry
Energy Industry
Good
Bad

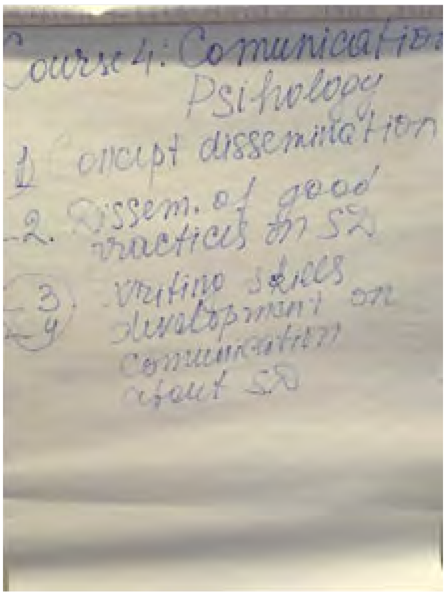
INDUSTRY
(COAL/DIAMOND/IRON ORE)
PLASTIC INDUSTRY

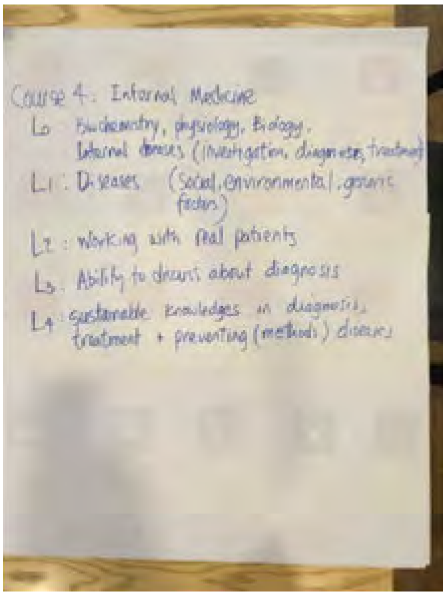
Agriculture

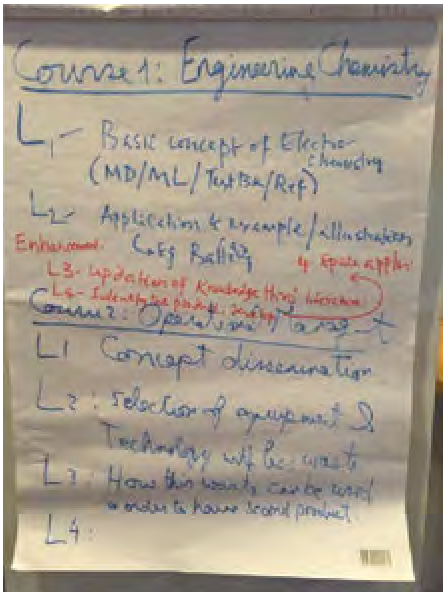

Course 1 : Mathematical Analysis
(Calculus)
L2: providing real-life examples related to both mathematical model & sustainable Development
No Enhancement needed
Course 2: International Environ-mental Law
L1: Introducing historical and legal regulations of SD
L2: Study good practices of other countries about SD
L3: Study the implementation of SD in Moldova
L4: Find international norms for effective application on the national

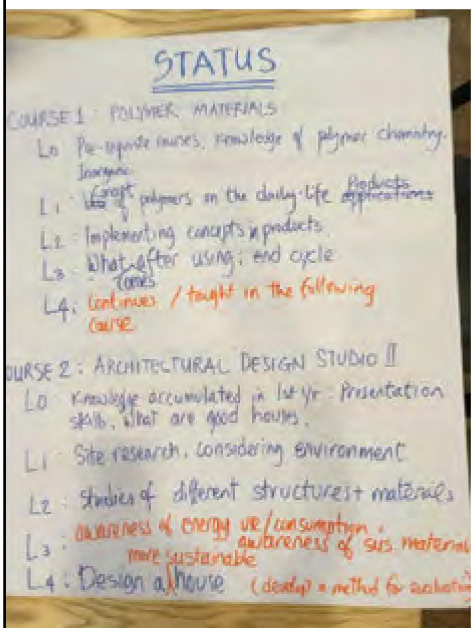

Course 3: Theories of Educational Evaluation
Level 1: Introduce the impact of Educational Evaluation on the quality of Education
Level 2: Identify real-life examples of good and bad aspects of educational evaluation
Level 3: ?
Level 4: Develop course embedded evaluation system to ensure the quality of the course which each student teaches

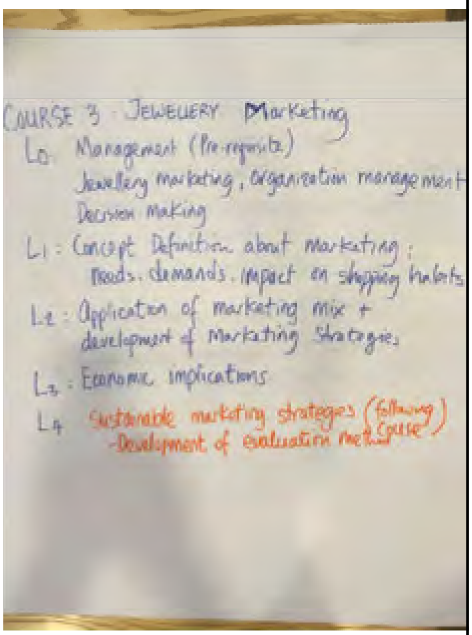

ourse 3: Machine Construction
1: How to design products with low cost
L2: Selection of a product + Reverse Engineering
L4: Design & Manufacture a product respecting L1 & L2


Course 4: Comunication Psihology
1) Concept dissemination
2. Dissem. of good practices on SD
3 4 writing skills development on communication about SD


Course 4: Internal Medicine
L0 Biochemistry, physiology, Biology.
Internal diseases (investigation, diagnoses, treatment)
L1: Diseases (Social, environmental, genetic factors)
L2: Working with real patients
L3: Ability to discuss about diagnosis
L4: sustainable knowledges in diagnosis, treatment + preventing (methods) diseases


Course 1: Engineering Chemistry
L1 – Basic concept of Electro-
(MD/ML/TextBk/Ref)
L2 – Application & example/illustrations
L4:


STATUS
COURSE 1: POLYMER MATERIALS
L0 Pre-requisite courses: knowledge of polymer chemistry.
L1: polymers in the daily life
L2: Implementing concepts in products
L3: What after using: end cycle
L4: Continues / taught in the following course
COURSE 2: ARCHITECTURAL DESIGN STUDIO II
L0 Knowledge accumulated in 1st yr: Presentation skills. What are good houses.
L1: Site research. Considering environment
L2: Studies of different structures + materials
L3: awareness of energy use/consumption, awareness of sus. materials
more sustainable
L4: Design a house


COURSE 3: JEWELLERY Marketing
L0: Management (Pre-requisite)
Jewellery marketing, organization management
Decision Making
L1: Concept Definition about marketing: needs, demands, impact on shopping habits
L2: Application of marketing mix + development of Marketing Strategies
L3: Economic implications
L4: Sustainable marketing strategies (following course)
-Development of evaluation method

What's next?

Your way forward…

Today's theme:

Integration of Sustainable Development

Anders Rosén & Emma Strömberg

Enhancing Engineering Education
KTH Workshop Oct 2017

Who are we?

Dr. Emma Strömberg

- Associate professor in Polymeric materials at Fiber and Polymer Technology.
- Teaching Sustainable Development and Polymeric Science.
- Former program director for the Master program: Materials and Sensor Engineering for Environmental Sustainability.
- Working with strategic pedagogical development including integration of sustainable development in educational programs.

Dr. Anders Rosén

- Associate professor in Naval Architecture.
- Teaching Ship Design & High-speed Craft.
- Program director for the Master program: Naval Architecture.
- Working with pedagogical development and CDIO.

Today's agenda

- What is sustainable development?
- How is the state of the world?
- What can we do about it?

What is sustainable development?

What is Sustainable Development?

Please turn to your neighbour and discuss for 5 minutes :

- What is it that should be sustained ?
- What is it that should be developed ?

What is Sustainable Development?

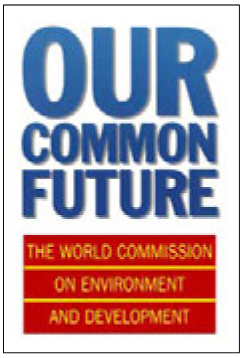
Sustainable development is a vague and highly complex concept that is difficult to understand and subject to endless definition and re-definition…

Just like other important concepts, such as democracy, welfare and justice, sustainable development is not subject to an analytically precise definition…

(Cruickshank & Fenner 2012)

This however doesn't make it less important!

The first ”definition” of Sustainable Development



…also known as the Brundtland Report,
by the United Nations World Commission on Environment and Development (WCED), 1987.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Contains two key concepts:

1. the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
2. the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

Sustainability principles according to The Natural Step

In a sustainable society, nature is not subject to systematically increasing:

1) concentrations of substances extracted from the earth's crust (e.g. heavy metals and CO2 from fossil fuels);

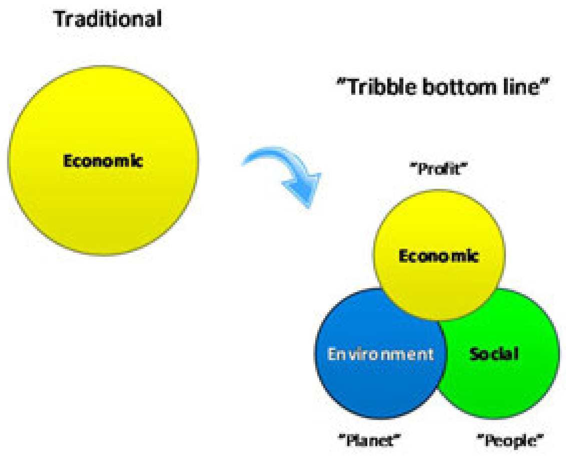
2) concentrations of substances produced by society (e.g. antibiotics, plastics, dioxins)

3) degradation by physical means (e.g. deforestation, destroying habitat, overfishing, draining groundwater tables);

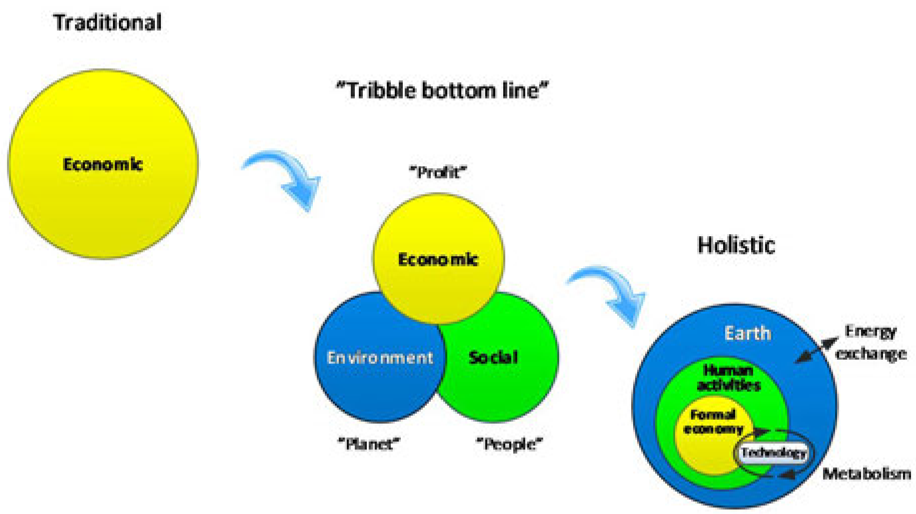
4) And in that society, there are no structural obstacles to people’s health, influence, competence, impartiality and meaning (e.g. unsafe working conditions, not enough pay to live on).

http://www.thenaturalstep.org/our-approach/

Three dimesions of Sustainable Development



Three dimesions of Sustainable Development



Three dimesions of Sustainable Development

…reflected in the degree qualifiers in the Swedish Higher Education Ordinance for the Master of Science in Engineering Degree:

9. demonstrate an ability to develop and design products, processes and systems taking into account people's situations and needs and the **society's objectives for economically, socially and ecologically sustainable development**;

14. demonstrate insight into the potential and limitations of technology and science, its role in society and people's responsibility for how it is used, **including social and economic aspects, as well as environmental and work environment aspects**;

How is the state of the world?

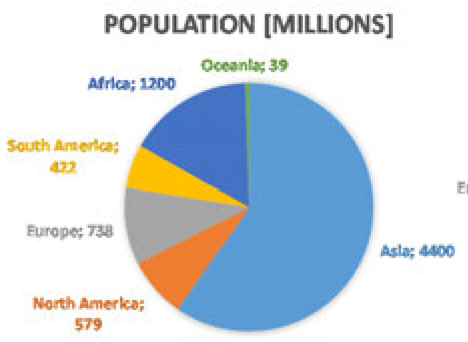
How is the state of the world?

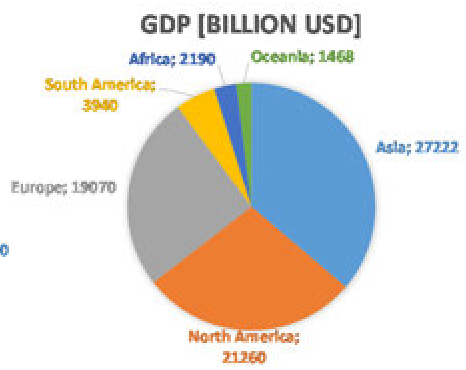
Workshop A

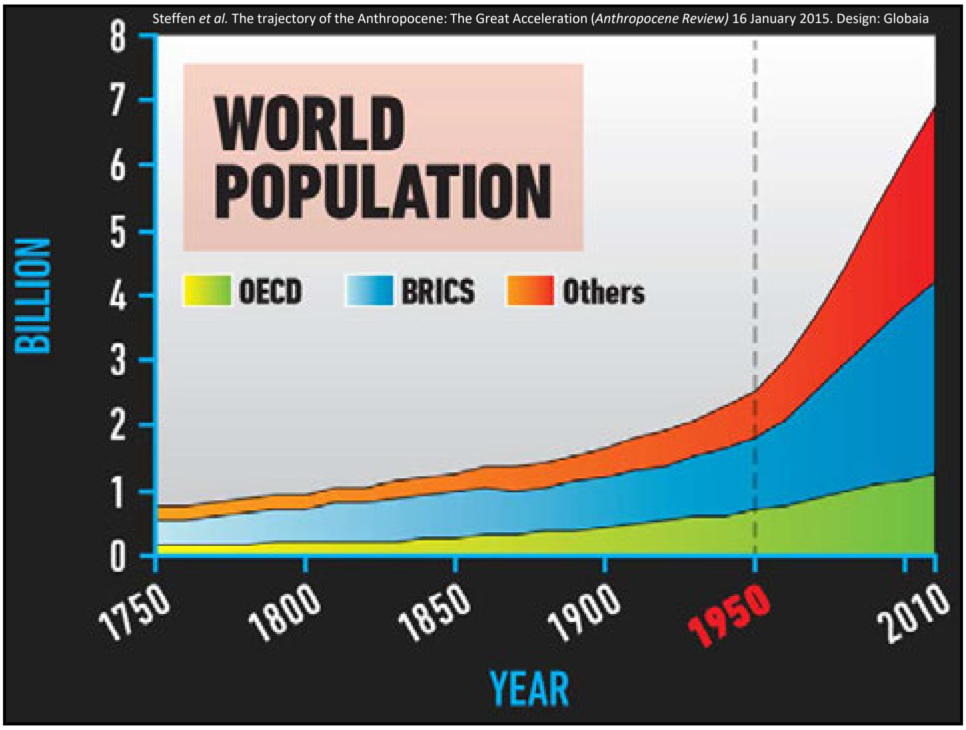
"Fika" challenge…

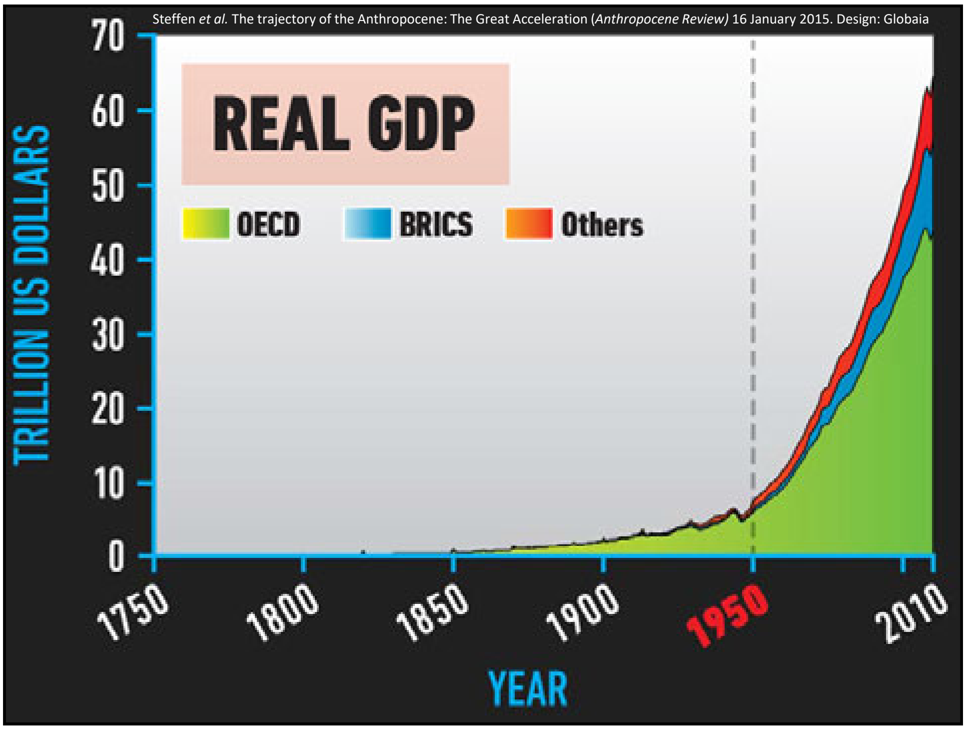
How is the state of the world?

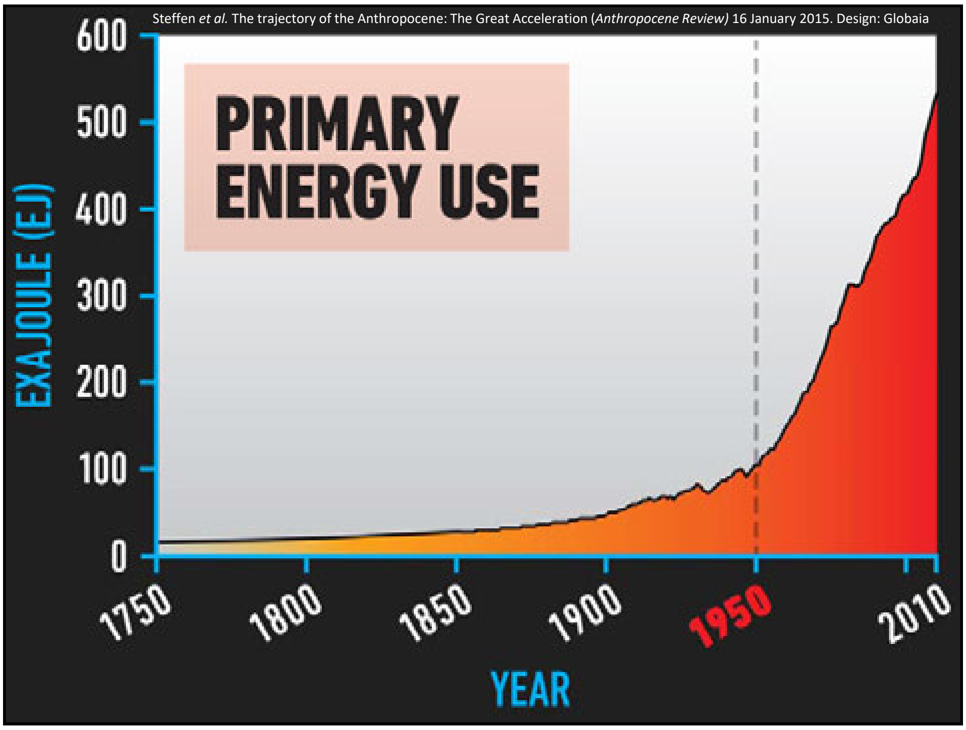
"Fika" challenge…

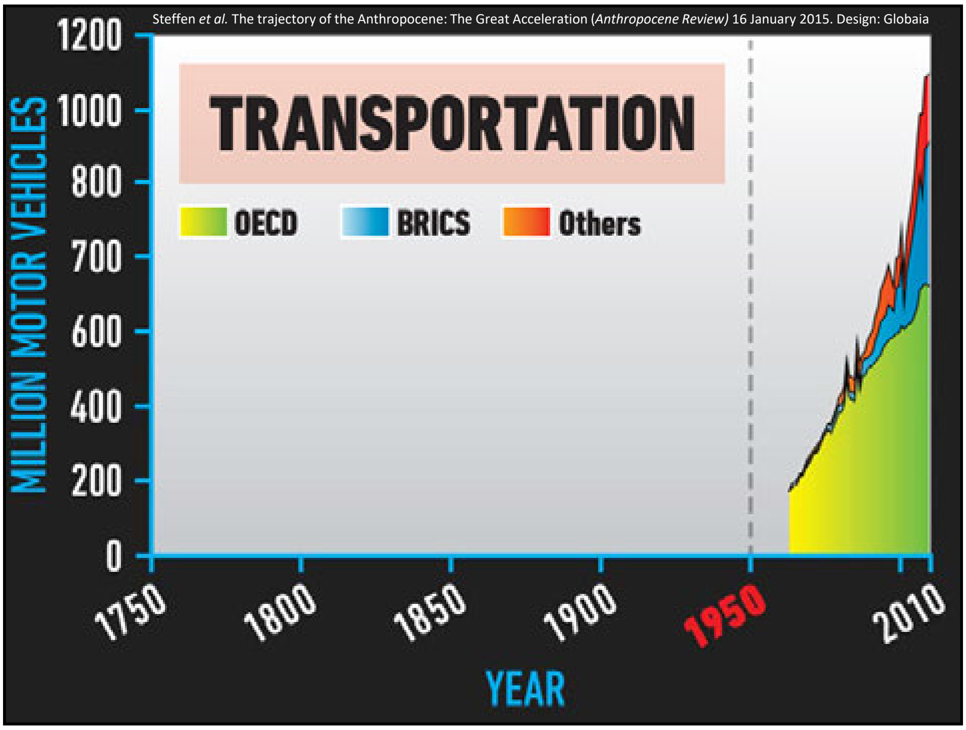


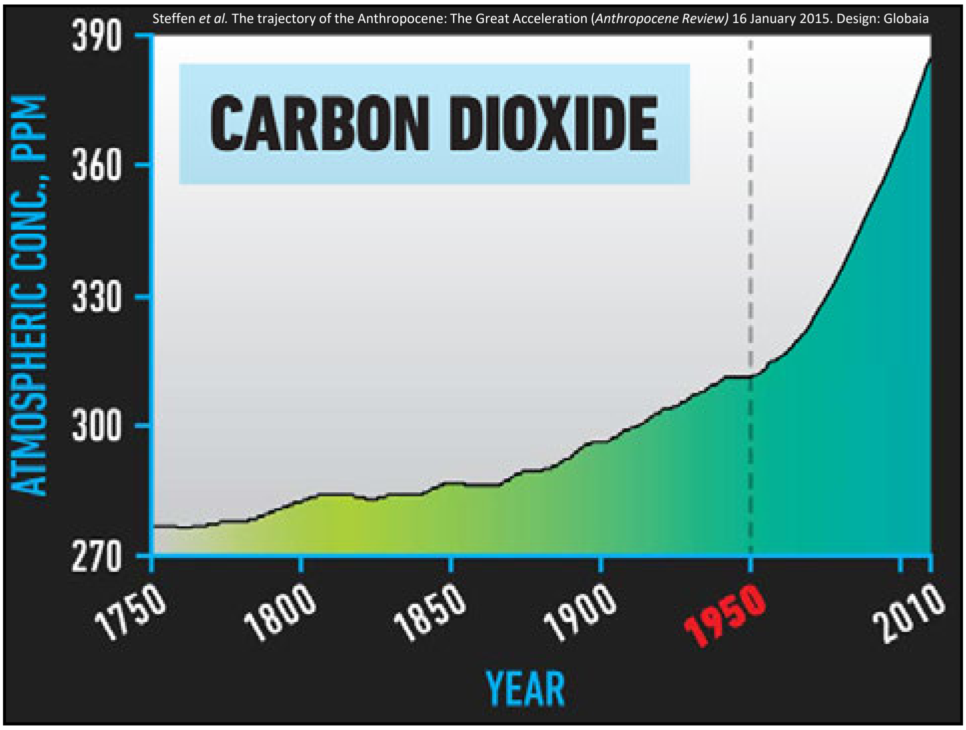


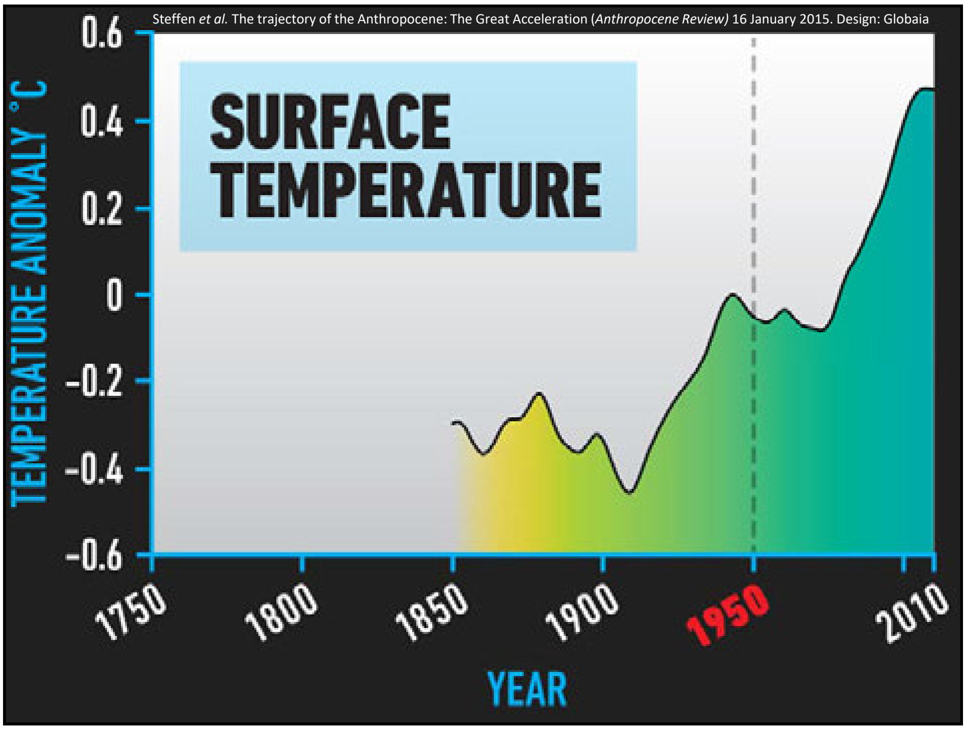

Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
WORLD POPULATION
OECD
BRICS
Others
BILLION
0
1
2
3
4
5
6
7
8
1750
1800
1850
1900
1950
2010
YEAR

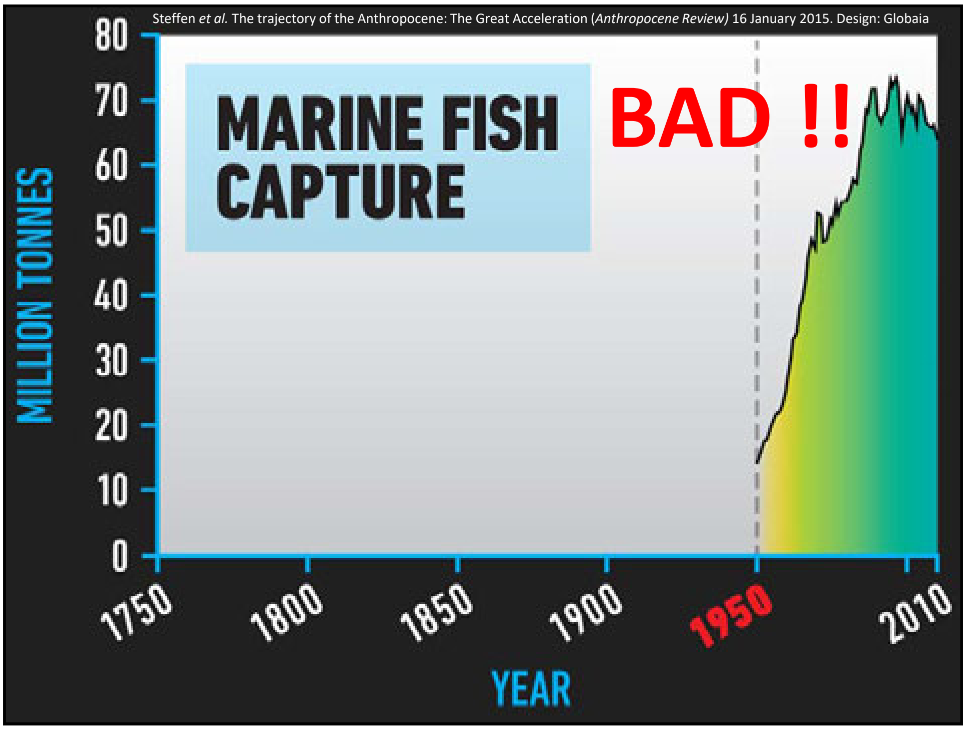

Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
REAL GDP
OECD
BRICS
Others
TRILLION US DOLLARS
0
10
20
30
40
50
60
70
1750
1800
1850
1900
1950
2010
YEAR

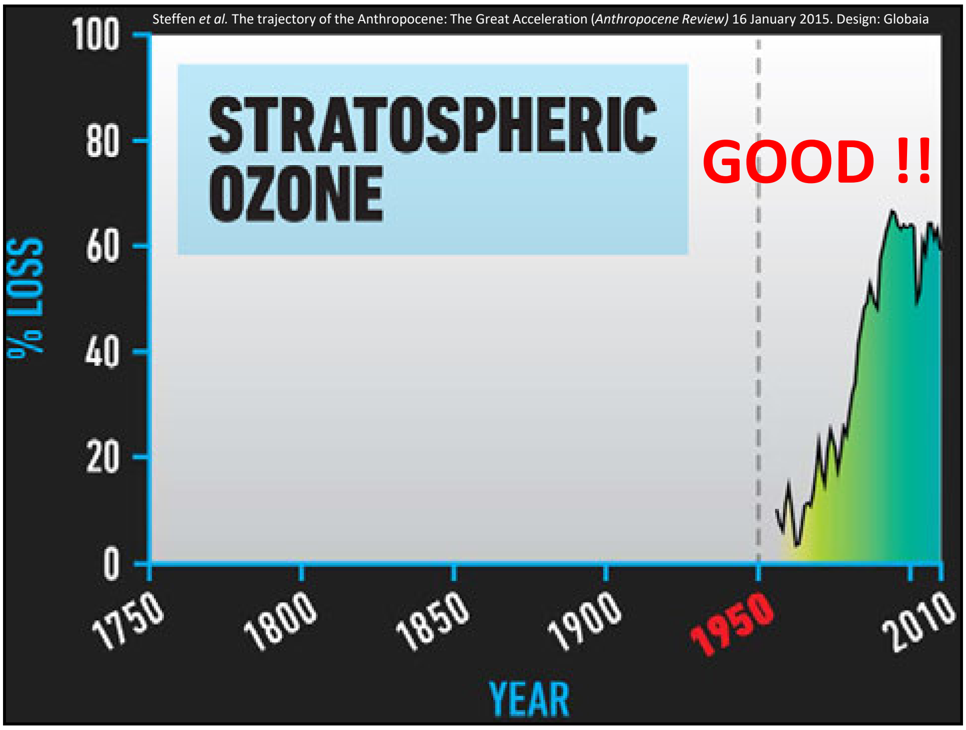

Steffen *et al.* The trajectory of the Anthropocene: The Great Acceleration (*Anthropocene Review*) 16 January 2015. Design: Globaia
PRIMARY ENERGY USE
EXAJOULE (EJ)
600
500
400
300
200
100
0
1750
1800
1850
1900
1950
2010
YEAR


Steffen *et al.* The trajectory of the Anthropocene: The Great Acceleration (*Anthropocene Review*) 16 January 2015. Design: Globaia
TRANSPORTATION
OECD
BRICS
Others
MILLION MOTOR VEHICLES
1200
1000
800
700
600
400
200
0
1750
1800
1850
1900
1950
2010
YEAR


Steffen *et al.* The trajectory of the Anthropocene: The Great Acceleration (*Anthropocene Review*) 16 January 2015. Design: Globaia
CARBON DIOXIDE
ATMOSPHERIC CONC., PPM
390
360
330
300
270
1750
1800
1850
1900
1950
2010
YEAR

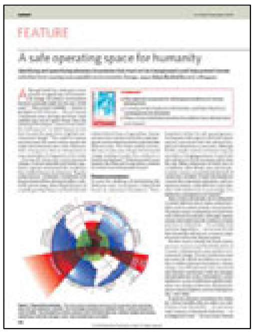

Steffen *et al.* The trajectory of the Anthropocene: The Great Acceleration (*Anthropocene Review*) 16 January 2015. Design: Globaia
SURFACE
TEMPERATURE
TEMPERATURE ANOMALY °C
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1750
1800
1850
1900
1950
2010
YEAR


Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
MARINE FISH CAPTURE
BAD !!
MILLION TONNES
80
70
60
50
40
30
20
10
0
1750
1800
1850
1900
1950
2010
YEAR

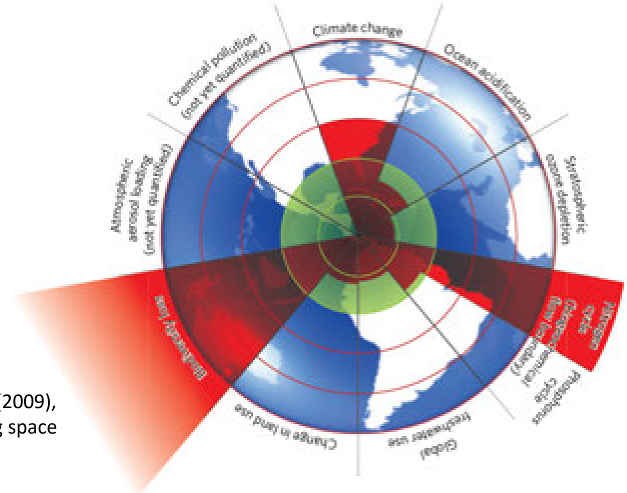

Steffen et al. The trajectory of the Anthropocene: The Great Acceleration (Anthropocene Review) 16 January 2015. Design: Globaia
STRATOSPHERIC OZONE
GOOD !!
% LOSS
100
80
60
40
20
0
1750
1800
1850
1900
1950
2010
YEAR

How is the state of the world?

Research based status descriptions


FEATURE

A safe operating space for humanity



Rockström et al (2009), ”A safe operating space for humanity”, identifying and quantifying planetary boundaries.

How is the state of the world?

Research based status descriptions

http://www.gapminder.org/answers/how-did-the-world-population-change/

Hans Rosling got the KTH Great Prize in 2010.

Now let's do some workshopping!

How is the state of the world?

Workshop groups

Grupp 1

Ahmed Elsabbagh	Ain Sham University, Egypt
Chinandu Mwendapole	Botho University, Botswana
Eunice Ja Young Kim	Korea University, South Korea
Andrei Popa	SUCahul, Moldova
Rodica Bugai	SUMPh, Moldova

Grupp 2

Mohamed Abdelaziz	Ain Sham University, Egypt
Suresh Shanmugasundaram	Botho University, Botswana
Liudmila Rosca-Sadruschi	SUCahul, Moldova
Mariana Spatari	USARB, Moldova
Liliana Turcan	USM, Moldova

Grupp 3

Mohamed Sheirah	Ain Sham University, Egypt
Eunju Jung	Korea University, South Korea
Natalia Gasitoi	USARB, Moldova
Natalia Zamfir	USM, Moldova
Dinu Turcanu	UTM, Moldova

Grupp 4

Tamer Elnady	Ain Sham University, Egypt
Venkataraman Vishwanathan	Botho University, Botswana
Victoria Rotaru	SUMPh, Moldova
Valentina Pritcan	USARB, Moldova
Otilia Dandara	USM, Moldova
Larisa Bugaian	UTM, Moldova

How is the state of the world?

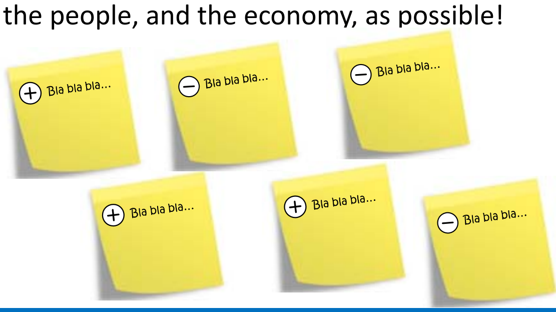
Workshop B / Part 1

- Which are the potentially good and bad influences from [industry sector] on the environment, people, and economy?
- Decide in the group on a suiting [industry sector] to workshop on.
- Declare after 5 minutes.

How is the state of the world?

Workshop B / Part 2

- Which are the potentially good and bad influences from [industry sector] on the environment, people, and economy?
- Brainstorm in your groups! Try to formulate as many good ⊕ and bad ⊖ influences (direct and/or indirect) on the environment, the people, and the economy, as possible!



Brain storming ”rules”:
- Go for quantity. Try to get 100 ideas!
- Encourage wild ideas. There are no right or wrong ideas.
- Don´t critique or debate ideas.
- Try building on each others ideas.

Recalling today's agenda…

- What is sustainable development?
- How is the state of the world?
- What can we do about it?

What can we do about it?

What can we do about it?

Technical development - Examples

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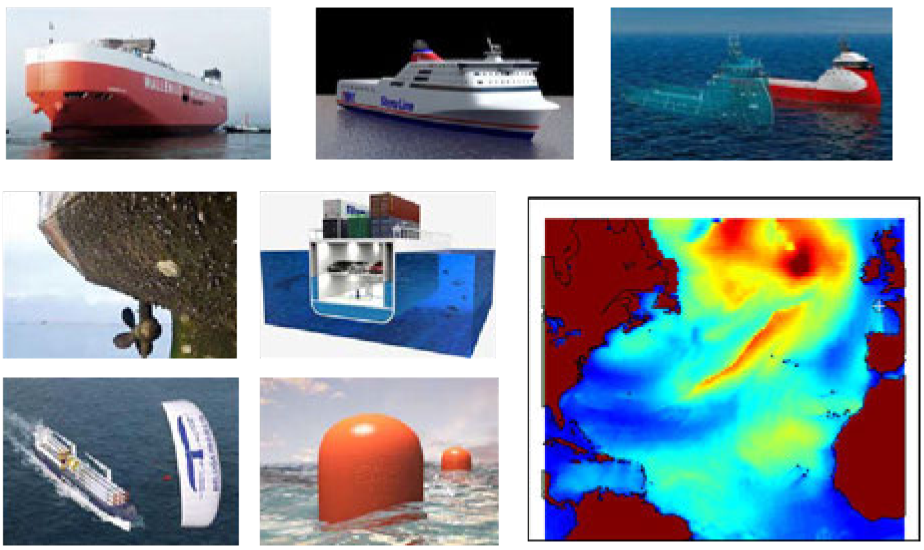
What can we do about it?

Technical development - Examples



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What can we do about it?

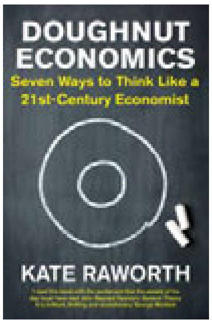
Will technical development solve everything ?

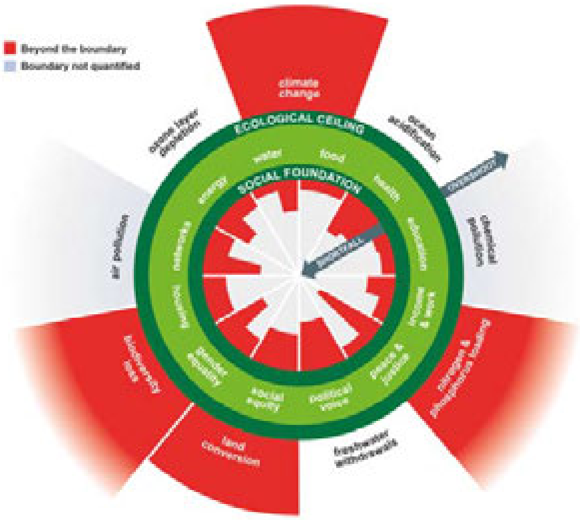
What can we do about it?

Changing lifestyles

What can we do about it?

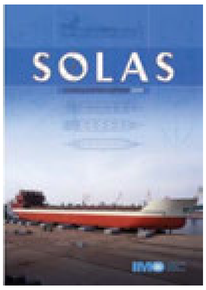
New economic principles

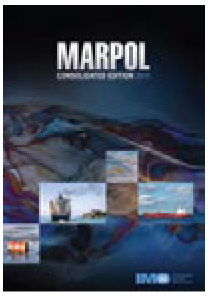


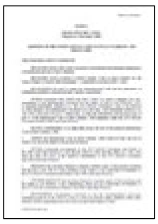


What can we do about it?

Policies, agreements, regulations







International, eg
IMO 2008 Intact Stability Code

International, eg
Classification Rules

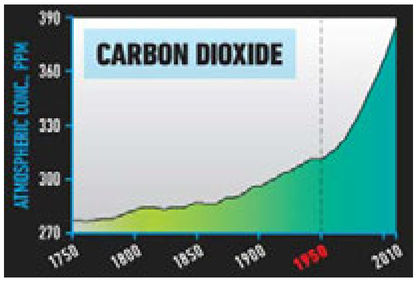
National, eg
Transportstyrelsens
författningssamling

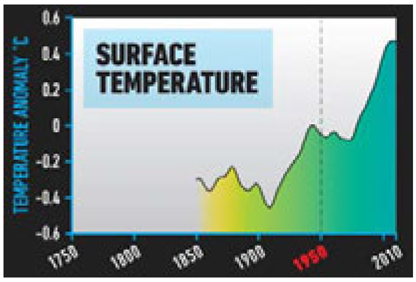
What can we do about it?

Policies, agreements, regulations

ADOPTION OF THE PARIS AGREEMENT

Proposal by the President





What can we do about it?

Policies, agreements, regulations

BUSINESS BACKS LOW-CARBON USA

Dear President Trump, Members of the US Congress, and Global Leaders:

We call on our elected US leaders to strongly support:

1. Continuation of low-carbon policies to allow the US to meet or exceed our promised national commitment and to increase our nation's future ambition
2. Investment in the low carbon economy at home and abroad in order to give financial decision-makers clarity and boost the confidence of investors worldwide
3. Continued US participation in the Paris Agreement, in order to provide the long-term direction needed to keep global temperature rise below 2°C

What can we do about it?

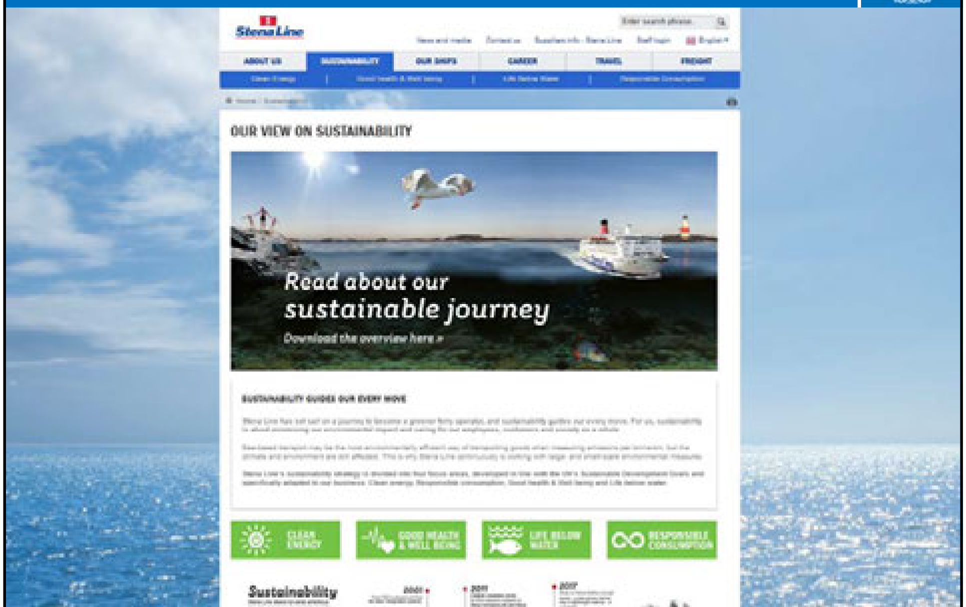
Policies, agreements, regulations

http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

http://www.undp.org/content/undp/en/home/librarypage/corporate/sustainable-development-goals-booklet.html

What can we do about it?

Policies, agreements, regulations



Let's continue workshopping!

Workshop B / Part 3

- Which are the potentially good and bad influences from [industry sector] on the environment, people, and economy?
- Brainstorm in your groups! Try to formulate as many good ⊕ and bad ⊖ influences (direct and/or indirect) on the environment, the people, and the economy, as possible!
- Now try to categorize your goods and bads in relation to the Sustainable Development Goals. Add more if you can.
- Present your results on a poster.

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Recalling today's agenda…

- What is sustainable development?
- How is the state of the world?
- What can we do about it?
  - Technical development.
  - New economic principles.
  - Policies, agreements, regulations.
  - What is KTH doing about it?
  - What could you do about it in your educations?

Now time for lunch!

Let's continue at 13…

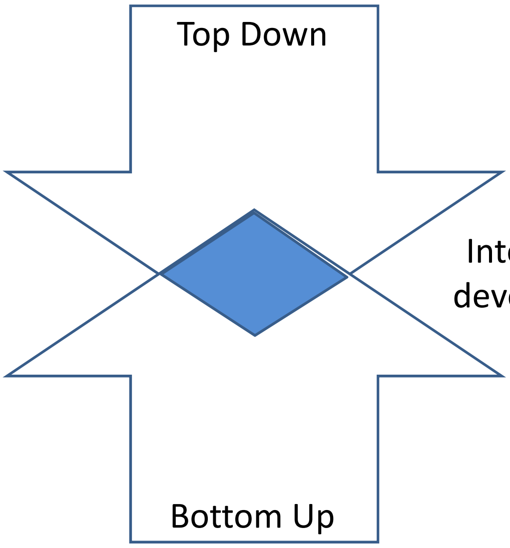
What is KTH doing about it?

Emma
talks about KTH…

Anders
introduces SDII…

What can we do about it?

Top Down vs Bottom Up



Integration of sustainable development in educations

What can we do about it?

Integration of Sustainable Development

How coud we teachers talk about and collaborate on integration of sustainable development in our teaching?

What can we do about it?

Sustainable Development Integration Indicators

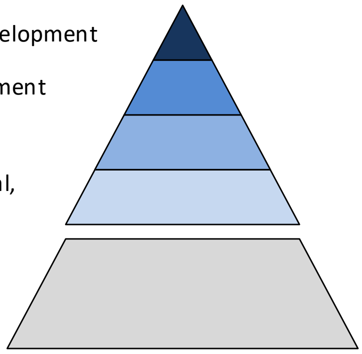
Level 4 : Specific skills for Sustainable Development

Level 3 : Literacy for Sustainable Development

Level 2 : Engineering applications

Level 1 : Exposure to environmental, social, and economic aspects

Core disciplinary knowledge



Rosén (2017)

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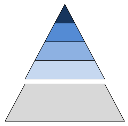
Now let's do some more workshopping!

What can we do about it?

Workshop C / Part 1 – *Status*

1. Form groups of 4-5 members.
2. Shortly present the course you've chosen to bring to the workshop to eachother.
3. Discuss and try to categorized the levels (0-4) of integration of sustainable development in each of the presented courses.
4. Present your results on a poster.



Status

Course 1 name
L2: bla bla bla bla bla...
bla bla bla bla bla...
L1: bla bla bla...

Course 2 name
L0

Course 3 name
L3: bla bla bla bla bla...
bla bla bla...
L2: bla bla bla bla bla...
bla bla...
L1: bla bla bla bla bla...

Course 4 name
L0

Examples of integration of sustainable development in KTH courses

Emma talks about her courses…

Anders talks about his courses…

Example of integration of sustainable development in the course

SD2705 High-Speed Craft (6 ECTS)

…is there anything more environmentally hostile?

Sometimes they're needed!

Example of integration of sustainable development in the course

SD2705 High-Speed Craft (6 ECTS)

Learning Objectives:

The objective is that you after finishing the course shall be able to:

1. Demonstrate broad knowledge and understanding of the scientific basis and proven experience of high-speed craft design, deeper methodological knowledge, and insight into current research and development work.

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

a) formulate and analyse design requirements for high-speed craft;
b) identify and formulate the related design challenges;
c) create, analyse and evaluate different solutions for the hull structure and other parts of high-speed craft.

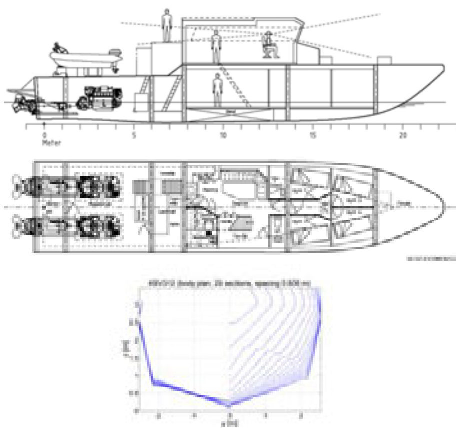
3. Demonstrate an ability to clearly present and discuss high-speed craft design aspects with reference to relevant theory and with use of appropriate terminology, orally as well as in writing in dialogue with different groups.

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

Example of integration of sustainable development in the course

SD2705 High-Speed Craft (6 ECTS)

- Design the propulsion system and the hull structure for a search and rescue craft, based on the following requirements:



Length	24	m
Beam	5	m
Deadrise at L/2	20	deg
Displacement, design	48	ton
Draft (at design displacement)	1.17	m
Service speed in calm water	30	kn
Range at top speed	300	Nm
Operational profile, 2000h/yr		
30kn	25	%
20 kn	50	%
10 kn	20	%
5 kn	5	%

DNV class notation +1A1 R1 HSLC Patrol E0

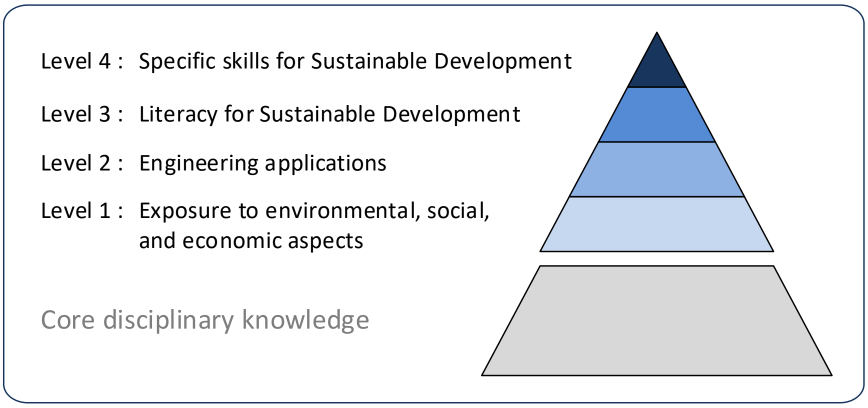
Example of integration of sustainable development in the course

SD2705 High-Speed Craft (6 ECTS)

Trough the course the students are challenged with considering conflicting requirements and discuss and decide on appropriate trade-offs:

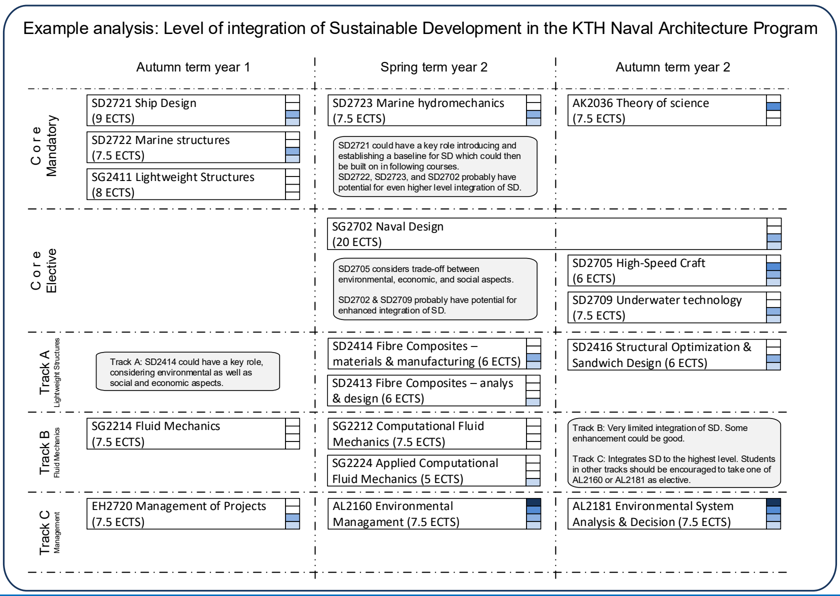
- **Social** motivation **for** travelling at high speed:
  - In the first home assignment the students should read an article from the journal *Professional Boatbuilder* about a case study for a high-speed search and rescue boat (*"…most offshore boating accident deaths results from hypotherimia and not from drowning… make it clear that to be effective any search-and-rescue boat must be fast and ready to get under way quickly"*)
- **Social** motivation **against** travelling at high speed:
  - High speed in waves generate violent craft motions which are fatiguing for the crew an even might result in severe crew injuries
- **Economic** motivation **against** travelling at high speed:
  - High speed in waves generate large hydrodynamic loads which require a strong and heavy hull structure which in turn result in large material consumption, high building cost, large craft weight, large resistance through the water, high fuel consumtion, and high operational cost
- **Environmental** motivation **against** travelling at high speed:
  - …high fuel consumption, large environmental impact.

Example of characterization & enhancement of the level of integration of sustainable development in an educational program



Rosén (2017)

Example of characterization & enhancement of the level of integration of sustainable development in an educational program



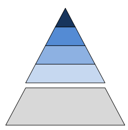
Rosén (2017)

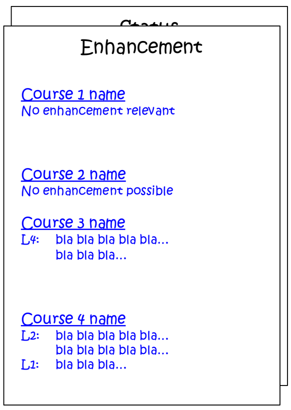
Let's continue workshopping!

What can we do about it?

Workshop C / Part 2 – Enhancement

1. Get back to your groups.
2. Discuss if and how the level of integration of sustainable development could be enhanced in each of the courses.
3. Present your results on a poster.

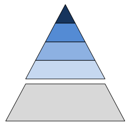




What can we do about it?

Workshop C / Part 3 – Global Goals

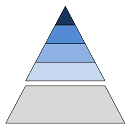
1. Get back to your groups.
2. Discuss if and how the courses relates to the Global Goals.
3. Present your results on a poster.



What can we do about it?

Workshop C / Part 4 – Learning outcomes

1. Get back to your groups.
2. Together sketch sustainable development related intended learning outcomes for your courses!
3. Present your results on a poster.



Learning Outcomes

After finishing the course the student shall be able to…

Course 1 name
- explain…
- reflect on…
- quantify…

Course 2 name
NA

Course 3 name
- demonstrate…
- critically discuss…

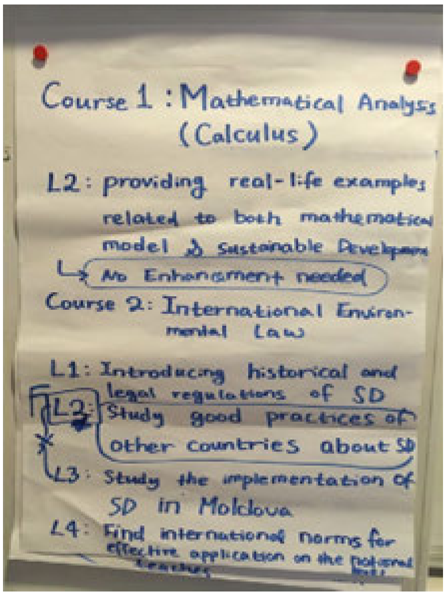
Course 4 name
- identify…
- evaluate…
- …

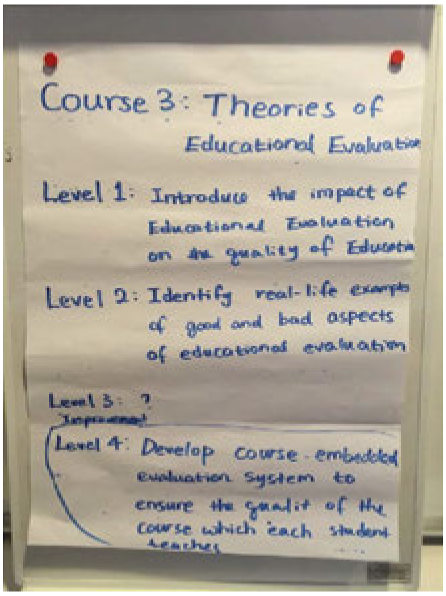

Cement Industry
Energy Industry
Good
Bad

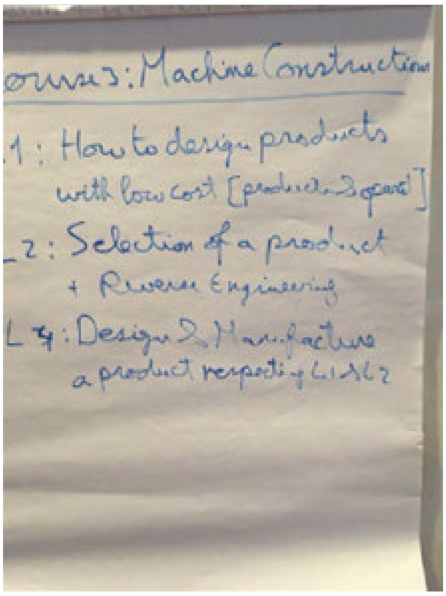

(COAL/DIAMOND/IRON ORE)

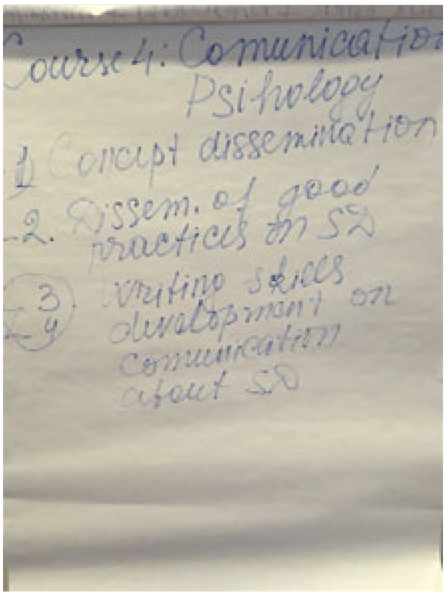

PLASTIC INDUSTRY

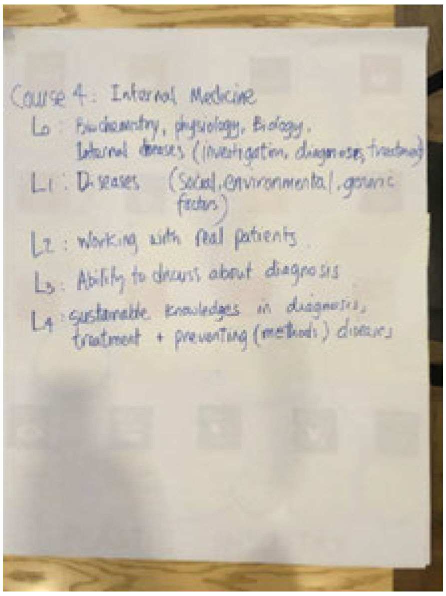

Agriculture

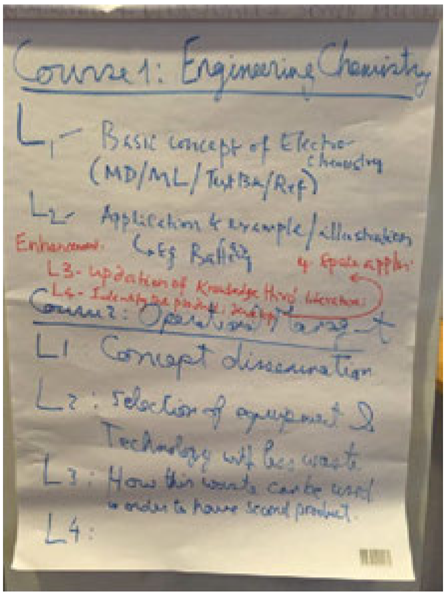

Course 1 : Mathematical Analysis
(Calculus)
L2: providing real-life examples
related to both mathematical
model & Sustainable Development
No Enhancement needed
Course 2: International Environmental Law
L1: Introducing historical and
legal regulations of SD
L2: Study good practices of
other countries about SD
L3: Study the implementation of
SD in Moldova
L4: Find international norms for
effective application on the national

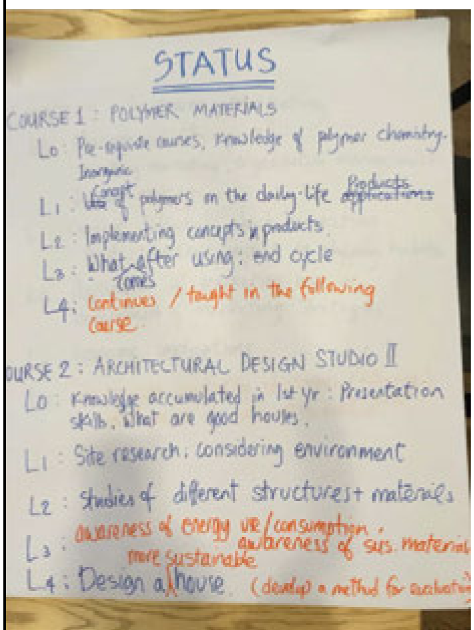

Course 3: Theories of
Educational Evaluation
Level 1: Introduce the impact of
Educational Evaluation
on the quality of Education
Level 2: Identify real-life examples
of good and bad aspects
of educational evaluation
Level 3: ?
Level 4: Develop course-embedded
evaluation system to
ensure the quality of the
course which each student
teaches

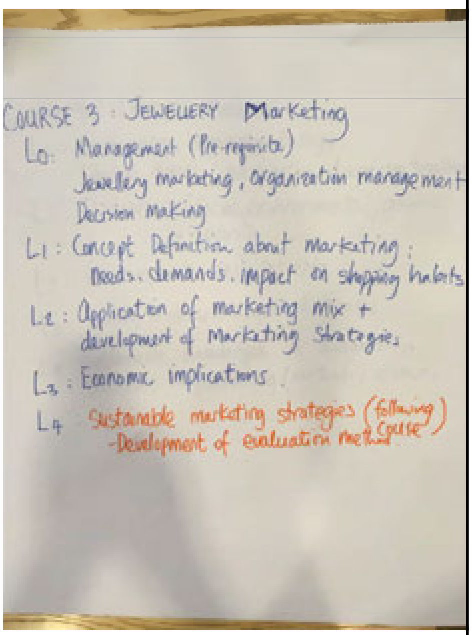

ourse 3: Machine Construction
1: How to design products
with low cost [production & spare]
2: Selection of a product
+ Reverse Engineering
L4: Design & Manufacture
a product respecting L1&L2


Course 4: Comunication
Psihology
1 Concept dissemination
2. Dissem. of good
practices on SD
3
4
writing skills
development on
communication
about SD


Course 4: Internal Medicine
L0: Biochemistry, physiology, Biology.
Internal diseases (investigation, diagnoses, treatment)
L1: Diseases (Social, environmental, genetic factors)
L2: Working with real patients
L3: Ability to discuss about diagnosis
L4: sustainable knowledges in diagnosis, treatment + preventing (methods) diseases


Course 1: Engineering Chemistry
L1 – Basic concept of Electro-chemistry
(MD/ML/TutBa/Ref)
L2 – Application & example/illustration
Enhancement. Eg Battery
L3 – updation of Knowledge thro' literature
Course 2: Operation ...
L1 Concept dissemination
L2: Selection of equipment & Technology with less waste
L3: How this waste can be used in order to have second product.
L4:


STATUS
COURSE 1: POLYMER MATERIALS
L0: Pre-requisite courses, knowledge of polymer chemistry.
L1: Concept polymers on the daily life Products applications
L2: Implementing concepts in products
L3: What comes after using: end cycle
L4: continues / taught in the following course
COURSE 2: ARCHITECTURAL DESIGN STUDIO II
L0: Knowledge accumulated in 1st yr: Presentation skills, What are good houses.
L1: Site research; considering environment
L2: Studies of different structures + materials
L3: awareness of energy use/consumption, awareness of sus. materials, more sustainable
L4: Design a house (develop a method for evaluation


COURSE 3: JEWELLERY Marketing
L0: Management (Pre-requisite)
Jewellery marketing, organization management
Decision making
L1: Concept Definition about marketing: needs, demands, impact on shopping habits
L2: Application of marketing mix + development of Marketing Strategies
L3: Economic implications
L4: Sustainable marketing strategies (following course)
-Development of evaluation method

What's next?

Your way forward…

KTH
VETENSKAP OCH KONST

Integration of Sustainable Development in Education at KTH

Emma Strömberg

How does one motivate a change?

Sustainable development goals

http://www.un.org/sustainabledevelopment/sustainable-development-goals/

KTH's sustainable development objectives for education 2016-2020

- KTH shall increase all employees' and students' knowledge of and involvement in issues relating to sustainable development.
- 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.

Sustainable development shall be integrated into **all of KTH's educational programs**, including doctoral programs. There should also be educational programs at all levels **with a sustainability focus**. In all architectural and five year engineering programs students should have an opportunity to develop a **sustainability profile** through selection of elective courses or the possibility to choose a master program or track with a sustainability focus. Within KTH's environmental management system, all schools shall establish an **action plan** on how to strengthen the integration of sustainable development into the school's educational programs. This may, if possible, be integrated with educational programs and development plans. **Evaluations, assignments and investigations** mandated centrally and related to education should include/integrate sustainable development. **A pedagogical course** on Learning for Sustainable Development should be held at least once a year. **Seminars and network meetings** for teaching staff shall be arranged. Employees and students at KTH shall be provided with knowledge and awareness of sustainable development relating to their work and student life. KTH will offer employees both **broad general education and necessary specialized training programs**, for example in chemical management. Future **quality assurance evaluations** shall include sustainable development.

Sustainable development in education: Two complementary approaches

Evaluation of the progress of integration of sustainable development on the program level

and

providing tools and support for Program directors and teaching staff to achieve the goals set by the university

Integration of sustainable development at the program level

2011 - EAE and career surveys pointed out the need for integration

2012 - all programs submitted self-assessments

2013 - follow-up through a dialogue with schools

2013 - all schools set up an action program for integration of sustainable development into their educational programs

2014 - all schools followed the action programs

2015 - a follow-up

2016 - new action programs set up

Follow-up

Three-step process

- Survey containing courses that contribute to fulfillment of the learning outcomes
- Interview with Program directors
- Summary for each educational program

Reflections after the follow-up

- Sustainable development is a natural part of education at KTH
- Clear effects of targeted initiatives in 2012 (8MSEK)
- Key factor – support from the school leaders
- Several programs need to focus on progression within the program
- The action plans need to be supported and fulfilled
- Important to follow up with programs that have stagnated
- Activities from KTH Sustainability Office have pushed the development forward

Tools for integration of sustainable development in educational programs

- Clarification of the overall learning outcomes
- Mapping of courses and programs with ESD-relevance
- "Coaching" of teachers and Program directors, contact information on teacher resources
- Pedagogical course - Learning for Sustainable Development
- Development of a Toolbox for Teachers
- Development of course modules
- Seminars and networking

Overall learning outcomes in the Swedish Higher Education Act

Competence and skills

demonstrate the ability to develop and design products, processes and systems while taking into account the circumstances and needs of individuals and the targets for economically, socially and ecologically sustainable development set by the community.

Judgement and approach

demonstrate insight into the possibilities and limitations of technology, its role in society and the responsibility of the individual for how it is used, including both social and economic aspects and also environmental and occupational health and safety considerations.

Clarification of the overall learning outcomes

The overall learning outcomes can be seen as too general

10 specific goals presented in 2012

Tools for program and course development

Tools for evaluation

Serve as advisory goals

Revised in 2014


Precisering av övergripande lärandemål för miljö och hållbar utveckling

Tools for integration of sustainable development in educational programs

- Clarification of the overall learning outcomes
- Mapping of courses and programs with ESD-relevance
- "Coaching" of teachers and Program directors, contact information on teacher resources
- Pedagogical course - Learning for Sustainable Development
- Development of a Toolbox for Teachers
- Development of course modules
- Seminars and networking

Pedagogical issues

- Introduction of sustainability concept
- Progression within the program
- Examination
- Judgement free environment

Learning for Sustainable development

The general aim of the course is that teachers, based on their own subject, should be able to integrate questions on sustainable development in their teaching so that the students, during and after their education include their integrated knowledge and reflections in the subject sustainable development.

- What is sustainable development?
- Integration and progression
- What is sustainable development for engineers?
- What is learning for sustainable development?
- Course goals, activities and examination

School of Education and Communication in Engineering Science
Anna-Karin Högfeldt, Organisation and Leadership
Monika Olsson, Industrial Ecology

Learning for Sustainable development

Tools for integration of sustainable development in educational programs

- Clarification of the overall learning outcomes
- Mapping of courses and programs with ESD-relevance
- "Coaching" of teachers and Program directors, contact information on teacher resources
- Pedagogical course - Learning for Sustainable Development
- Development of a Toolbox for Teachers
- Development of course modules
- Seminars and networking

Toolbox – Education for Sustainable Development

Toolbox

http://www.kth.se/om/miljo-hallbar-utveckling/utbildning-miljo-hallbar-utveckling/verktygslada

Tools for integration of sustainable development in educational programs

- Clarification of the overall learning outcomes
- Mapping of courses and programs with ESD-relevance
- "Coaching" of teachers and Program directors, contact information on teacher resources
- Pedagogical course - Learning for Sustainable Development
- Development of a Toolbox for Teachers
- Development of course modules
- Seminars and networking

Jon-Erik Dahlin

Developed modules at KTH

Interactive Introduction to Sustainable Development –
board games and interactive lectures

Developed modules at KTH

Social sustainability in education at KTH

- Generic part – 4 lectures and 2 seminars
- Program specific part – developed in collaboration with the course responsible teacher

  (Elisabeth Ekener, Karin Edvardsson Björnberg, Niccolas Albiz, Dominic Von Martens)

ÅF/KTH – Sustainable business development

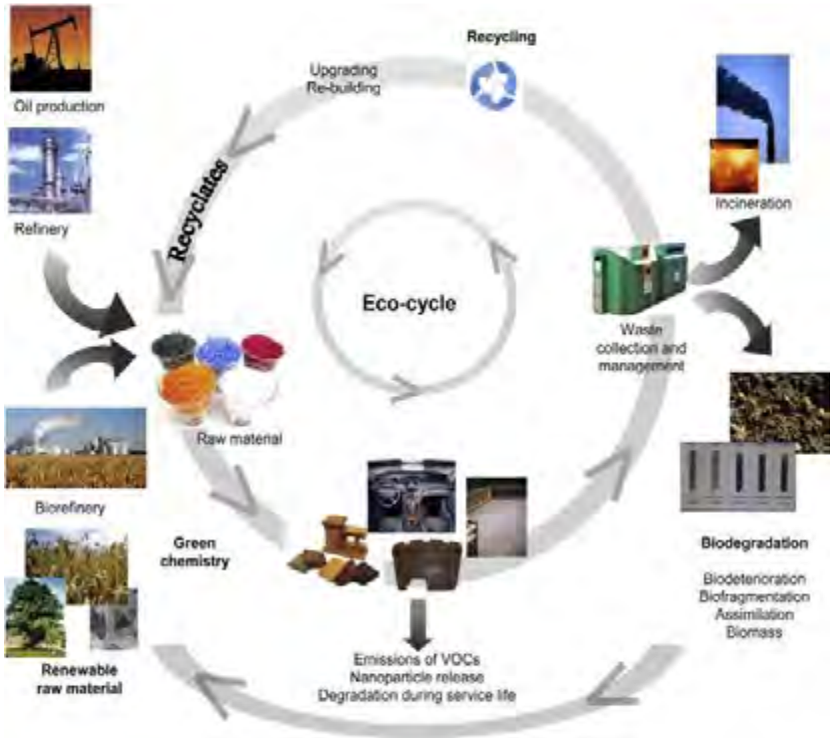
- Social Responsibility: An organization's responsibility towards society and the environment.
- Sustainable business: A business where sustainability is a key driver of business strategy, process and product development, and marketing.

Tools for integration of sustainable development in educational programs

- Clarification of the overall learning outcomes
- Mapping of courses and programs with ESD-relevance
- "Coaching" of teachers and Program directors, contact information on teacher resources
- Pedagogical course - Learning for Sustainable Development
- Development of a Toolbox for Teachers
- Development of course modules
- Seminars and networking

KTH-Sustainability Education Day

Teaching Sustainable development



F. Vilaplana, E. Strömberg, S. Karlsson; Polymer Degradation and Stability, 95, 11, 2010, 2147–2161

Discussion exercise

Change in lifestyle

Technology development

Economic aspects

Legislation

Discussion exercise

What needs to be done today for our grandchildren to have a good life?

Debate seminar

- Teacher-led debate about different sustainability principles
  - Ethical principles such as justice between generations, civic participation, global justice
  - Ecological principles such as biodiversity
  - Economic principles e.g. strategies for the future
- Each group discusses/argues with another group about a topic from a given role - about 20 minutes

Discussion between representatives of companies that develop new chemicals and chemical legislators

- In order to build a sustainable technical culture with the current standard, intensive technology development is required in many areas including new chemicals. To get permission to use these requires extensive tests according to the precautionary principle. Can the precautionary principle for new chemicals go too far? Has it already?

Biopolymers vs Biobased polymers

- Available renewable resources?
- Routs from raw material to product?
- Environmental impact?
  - Energy
  - Emissions
  - Long term effects
- Social responsibility

Degree of Master of Science in Engineering (Civilingenjörsexamen)

Scope

A degree of Master of Science in Engineering is obtained after the student has completed course requirements of 300 higher education credits.

Objectives

For a degree of Master of Science in Engineering, students must demonstrate the knowledge and skills required for them to work independently as a graduate engineer.

Knowledge and understanding

For a degree of Master of Science in Engineering students must
- demonstrate knowledge of the scientific basis and proven experience of their chosen area of engineering, together with insight into current research and development work; and
- demonstrate both broad knowledge in their chosen area of engineering, including knowledge of mathematics and natural sciences, and substantially deeper knowledge in certain parts of the field.

Skills and abilities

For a degree of Master of Science in Engineering students must
- demonstrate an ability, from a holistic perspective, to critically, independently and creatively identify, formulate and deal with complex issues, and to participate in research and development work so as to contribute to the development of knowledge;
- demonstrate an ability to create, analyse and critically evaluate different technical solutions;
- demonstrate an ability to plan and, using appropriate methods, carry out advanced tasks within specified parameters;
- demonstrate an ability to integrate knowledge critically and systematically and to model, simulate, predict and evaluate events even on the basis of limited information;
- demonstrate an ability to develop and design products, processes and systems taking into account people's situations and needs and society's objectives for economically, socially and ecologically sustainable development;
- demonstrate an ability to engage in teamwork and cooperation in groups of varying composition; and
- demonstrate an ability to clearly present and discuss their conclusions and the knowledge and arguments behind them, in dialogue with different groups, orally and in writing, in national and international contexts.

Judgement and approach

For a degree of Master of Science in Engineering students must
- demonstrate an ability to make assessments, taking into account relevant scientific, social and ethical aspects, and demonstrate an awareness of ethical aspects of research and development work;
- demonstrate insight into the potential and limitations of technology, its role in society and people's responsibility for its use, including social and economic aspects, as well as environmental and work environment aspects; and
- demonstrate an ability to identify their need of further knowledge and to continuously upgrade their capabilities.

Independent project (degree project)

For a degree of Master of Science in Engineering students must have completed an independent project (degree project) worth at least 30 higher education credits, within the framework of the course requirements.

Other

For a degree of Master of Science in Engineering more precise requirements are also to apply, as determined by each higher education institution itself within the framework of the requirements in this qualification description.

Degree of Bachelor of Science in Engineering *(Högskoleingenjörsexamen)*

Scope

A degree of Bachelor of Science in Engineering is obtained after the student has completed course requirements of 180 higher education credits.

Objectives

For a degree of Bachelor of Science in Engineering, students must demonstrate the knowledge and skills required for them to work independently as a university-educated engineer.

Knowledge and understanding

For a degree of Bachelor of Science in Engineering students must
- demonstrate knowledge of the scientific basis of their chosen area of engineering and its proven experience, as well as an awareness of current research and development work; and
- demonstrate broad knowledge in their chosen area of engineering and relevant knowledge in mathematics and natural sciences.

Skills and abilities

For a degree of Bachelor of Science in Engineering students must
- demonstrate an ability, taking a holistic approach, to independently and creatively identify, formulate and manage issues, and to analyse and assess different technical solutions;
- demonstrate an ability to plan and, using appropriate methods, carry out tasks within specified parameters;
- demonstrate an ability to use knowledge critically and systematically and to model, simulate, predict and evaluate events on the basis of relevant information;
- demonstrate an ability to design and manage products, processes and systems taking into account people's situations and needs and society's objectives for economically, socially and ecologically sustainable development;
- demonstrate an ability to engage in teamwork and cooperation in groups of varying composition; and
- demonstrate an ability to present and discuss information, problems and solutions in dialogue with different groups, orally and in writing.

Judgement and approach

For a degree of Bachelor of Science in Engineering students must
- demonstrate an ability to make assessments, taking into account relevant scientific, social and ethical aspects;
- demonstrate insight into the potential and limitations of technology, its role in society and people's responsibility for its use, including social and economic aspects, as well as environmental and work environment aspects; and
- demonstrate an ability to identify their need of further knowledge and to continuously upgrade their capabilities.

Independent project (degree project)

For a degree of Bachelor of Science in Engineering students must have completed an independent project (degree project) worth at least 15 higher education credits, within the framework of the course requirements.

Other

For a degree of Bachelor of Science in Engineering more precise requirements are also to apply, as determined by each higher education institution itself within the framework of the requirements in this qualification description.

Degree of Master (Two Years) (Masterexamen)

Scope

A Degree of Master (Two Years) is obtained after the student has completed course requirements of 120 higher education credits with a certain area of specialisation determined by each higher education institution itself, including at least 60 higher education credits with in-depth studies in the main field of study. In addition, the student must hold a Degree of Bachelor, a Degree of Bachelor of Arts in , a professional degree worth at least 180 higher education credits or an equivalent foreign qualification. Exceptions may be made to the requirement of a previous qualification for a student who has been admitted to the educational programme without having had basic eligibility in the form of a qualification. However, this does not apply if in the admissions process an exception has been made under Chapter 7, Section 28, second paragraph on the grounds that there has been insufficient time to issue a qualification certificate.

Objectives

Knowledge and understanding

For a Degree of Master (Two Years) students must
- demonstrate knowledge and understanding in their main field of study, including both broad knowledge in the field and substantially deeper knowledge of certain parts of the field, together with deeper insight into current research and development work; and
- demonstrate deeper methodological knowledge in their main field of study.

Skills and abilities

For a Degree of Master (Two Years) students must
- demonstrate an ability to critically and systematically integrate knowledge and to analyse, assess and deal with complex phenomena, issues and situations, even when limited information is available;
- demonstrate an ability to critically, independently and creatively identify and formulate issues and to plan and, using appropriate methods, carry out advanced tasks within specified time limits, so as to contribute to the development of knowledge and to evaluate this work;
- demonstrate an ability to clearly present and discuss their conclusions and the knowledge and arguments behind them, in dialogue with different groups, orally and in writing, in national and international contexts; and
- demonstrate the skill required to participate in research and development work or to work independently in other advanced contexts.

Judgement and approach

For a Degree of Master (Two Years) students must
- demonstrate an ability to make assessments in their main field of study, taking into account relevant scientific, social and ethical aspects, and demonstrate an awareness of ethical aspects of research and development work;
- demonstrate insight into the potential and limitations of science, its role in society and people's responsibility for how it is used; and
- demonstrate an ability to identify their need of further knowledge and to take responsibility for developing their knowledge.

Independent project (degree project)

For a Degree of Master (Two Years) students must have completed an independent project (degree project) worth at least 30 higher education credits in their main field of study, within the framework of the course requirements. The independent project may comprise less than 30 higher education credits, but not less than 15 higher education credits, if the student has already completed an independent project at the second level worth at least 15 higher education credits in their main field of study, or an equivalent project in a foreign educational programme.

Other

For a Degree of Master (Two Years) with a certain area of specialisation more precise requirements are also to apply, as determined by each higher education institution itself within the framework of the requirements in this qualification description.

Degree of Bachelor *(Kandidatexamen)*

Scope

A Degree of Bachelor is obtained after the student has completed course requirements of 180 higher education credits with a certain area of specialisation determined by each higher education institution itself, including at least 90 higher education credits with increasingly in-depth studies in the main field of study.

Objectives

Knowledge and understanding

For a Degree of Bachelor students must

- demonstrate knowledge and understanding in their main field of study, including knowledge of the scientific basis of the field, knowledge of applicable methods in the field, in-depth knowledge of some part of the field and a general sense of current research issues.

Skills and abilities

For a Degree of Bachelor students must
- demonstrate an ability to seek, gather and critically interpret information that is relevant to a problem and to critically discuss phenomena, issues and situations;
- demonstrate an ability to independently identify, formulate and solve problems and to perform tasks within specified time limits;
- demonstrate an ability to present and discuss information, problems and solutions in dialogue with different groups, orally and in writing; and
- demonstrate the skills required to work independently in the field that the education concerns.

Judgement and approach

For a Degree of Bachelor students must
- demonstrate an ability to make assessments in their main field of study, taking into account relevant scientific, social and ethical aspects;
- demonstrate insight into the role of knowledge in society and into people's responsibility for how knowledge is used; and
- demonstrate an ability to identify their need of further knowledge and to upgrade their capabilities.

Independent project (degree project)

For a Degree of Bachelor students must have completed an independent project (degree project) worth at least 15 higher education credits in their main field of study, within the framework of the course requirements.

Other

For a Degree of Bachelor with a certain area of specialisation more precise requirements are also to apply, as determined by each higher education institution itself within the framework of the requirements in this qualification description.

Degree of Master of Architecture (Arkitektexamen)

Scope

A degree of Master of Architecture is obtained after the student has completed course requirements of 300 higher education credits.

Objectives

For a degree of Master of Architecture, students must demonstrate the knowledge and skills required for them to work independently as an architect.

Knowledge and understanding

For a degree of Master of Architecture students must
- demonstrate knowledge of the scientific and artistic basis of the field and insight into relevant research and development work; and
- demonstrate both broad knowledge and understanding of the theory and history of architecture and deeper knowledge of architectural design, planning and development of built environments, together with the processes, methods and legislation that affect them.

Skills and abilities

For a degree of Master of Architecture students must
- demonstrate an ability to plan, design, preserve and renew built environments and buildings, from a holistic perspective and in complex contexts and taking account of different requirements, particularly society's objective of sustainable development;
- demonstrate an ability to critically, independently and creatively carry out and evaluate advanced and creative tasks within specified parameters in the field of architecture and planning, using appropriate architectural methods and syntheses;
- demonstrate an ability to apply knowledge of physical conditions and technical principles for erecting and modifying building structures;
- demonstrate an ability to engage in teamwork and cooperation in groups of varying composition;
- demonstrate an ability to clearly present and discuss their conclusions and the knowledge and arguments behind their conclusions in dialogue with different groups, using images and models, orally, in writing and in other ways, in both national and international contexts, so as to contribute to the profession and professional activities.

Judgement and approach

For a degree of Master of Architecture students must
- demonstrate an ability, from a holistic perspective, to factor in relevant scientific, social, aesthetic and ethical aspects in their assessments and considered choices, while taking account of the different needs and functional ability of society and of all people, as well as the interplay between people and the physical environment, including the work environment;
- demonstrate the potential to base their work on the requirement for long-term, functional solutions that are of high quality and good design; and
- demonstrate an ability to identify their need of further knowledge and to continuously upgrade their capabilities.

Independent project (degree project)

For a degree of Master of Architecture students must have completed an independent project (degree project) worth at least 30 higher education credits, within the framework of the course requirements.

Other

For a degree of Master of Architecture more precise requirements are also to apply, as determined by each higher education institution itself within the framework of the requirements in this qualification description.

Civilingenjörsexamen

Omfattning
Civilingenjörsexamen uppnås efter att studenten fullgjort kursfordringar om 300 högskolepoäng.

Mål
För civilingenjörsexamen skall studenten visa sådan kunskap och förmåga som krävs för att självständigt arbeta som civilingenjör.

Kunskap och förståelse
För civilingenjörsexamen skall studenten
- visa kunskap om det valda teknikområdets vetenskapliga grund och beprövade erfarenhet samt insikt i aktuellt forsknings- och utvecklingsarbete, och
- visa såväl brett kunnande inom det valda teknikområdet, inbegripet kunskaper i matematik och naturvetenskap, som väsentligt fördjupade kunskaper inom vissa delar av området.

Färdighet och förmåga
För civilingenjörsexamen skall studenten
- visa förmåga att med helhetssyn kritiskt, självständigt och kreativt identifiera, formulera och hantera komplexa frågeställningar samt att delta i forsknings- och utvecklingsarbete och därigenom bidra till kunskapsutvecklingen,
- visa förmåga att skapa, analysera och kritiskt utvärdera olika tekniska lösningar,
- visa förmåga att planera och med adekvata metoder genomföra kvalificerade uppgifter inom givna ramar,
- visa förmåga att kritiskt och systematiskt integrera kunskap samt visa förmåga att modellera, simulera, förutsäga och utvärdera skeenden även med begränsad information,
- visa förmåga att utveckla och utforma produkter, processer och system med hänsyn till människors förutsättningar och behov och samhällets mål för ekonomiskt, socialt och ekologiskt hållbar utveckling,
- visa förmåga till lagarbete och samverkan i grupper med olika sammansättning, och
- visa förmåga att i såväl nationella som internationella sammanhang muntligt och skriftligt i dialog med olika grupper klart redogöra för och diskutera sina slutsatser och den kunskap och de argument som ligger till grund för dessa.

Värderingsförmåga och förhållningssätt
För civilingenjörsexamen skall studenten
- visa förmåga att göra bedömningar med hänsyn till relevanta vetenskapliga, samhälleliga och etiska aspekter samt visa medvetenhet om etiska aspekter på forsknings- och utvecklingsarbete,
- visa insikt i teknikens möjligheter och begränsningar, dess roll i samhället och människors ansvar för hur den används, inbegripet sociala och ekonomiska aspekter samt miljö- och arbetsmiljöaspekter, och
- visa förmåga att identifiera sitt behov av ytterligare kunskap och att fortlöpande utveckla sin kompetens.

Självständigt arbete (examensarbete)
För civilingenjörsexamen skall studenten inom ramen för kursfordringarna ha fullgjort ett självständigt arbete (examensarbete) om minst 30 högskolepoäng.

Övrigt
För civilingenjörsexamen skall också de preciserade krav gälla som varje högskola själv bestämmer inom ramen för kraven i denna examensbeskrivning.

Högskoleingenjörsexamen

Omfattning
Högskoleingenjörsexamen uppnås efter att studenten fullgjort kursfordringar om 180 högskolepoäng.

Mål
För högskoleingenjörsexamen skall studenten visa sådan kunskap och förmåga som krävs för att självständigt arbeta som högskoleingenjör.

Kunskap och förståelse
För högskoleingenjörsexamen skall studenten
- visa kunskap om det valda teknikområdets vetenskapliga grund och dess beprövade erfarenhet samt kännedom om aktuellt forsknings- och utvecklingsarbete, och
- visa brett kunnande inom det valda teknikområdet och relevant kunskap i matematik och naturvetenskap.

Färdighet och förmåga
För högskoleingenjörsexamen skall studenten
- visa förmåga att med helhetssyn självständigt och kreativt identifiera, formulera och hantera frågeställningar och analysera och utvärdera olika tekniska lösningar,
- visa förmåga att planera och med adekvata metoder genomföra uppgifter inom givna ramar,
- visa förmåga att kritiskt och systematiskt använda kunskap samt att modellera, simulera, förutsäga och utvärdera skeenden med utgångspunkt i relevant information,
- visa förmåga att utforma och hantera produkter, processer och system med hänsyn till människors förutsättningar och behov och samhällets mål för ekonomiskt, socialt och ekologiskt hållbar utveckling,
- visa förmåga till lagarbete och samverkan i grupper med olika sammansättning, och
- visa förmåga att muntligt och skriftligt redogöra för och diskutera information, problem och lösningar i dialog med olika grupper.

Värderingsförmåga och förhållningssätt
För högskoleingenjörsexamen skall studenten
- visa förmåga att göra bedömningar med hänsyn till relevanta vetenskapliga, samhälleliga och etiska aspekter,
- visa insikt i teknikens möjligheter och begränsningar, dess roll i samhället och människors ansvar för dess nyttjande, inbegripet sociala och ekonomiska aspekter samt miljö- och arbetsmiljöaspekter, och
- visa förmåga att identifiera sitt behov av ytterligare kunskap och att fortlöpande utveckla sin kompetens.

Självständigt arbete (examensarbete)
För högskoleingenjörsexamen skall studenten inom ramen för kursfordringarna ha fullgjort ett självständigt arbete (examensarbete) om minst 15 högskolepoäng.

Övrigt
För högskoleingenjörsexamen skall också de preciserade krav gälla som varje högskola själv bestämmer inom ramen för kraven i denna examensbeskrivning.

Masterexamen

Omfattning
Masterexamen uppnås efter att studenten fullgjort kursfordringar om 120 högskolepoäng med viss inriktning som varje högskola själv bestämmer, varav minst 60 högskolepoäng med fördjupning inom det huvudsakliga området (huvudområdet) för utbildningen. Därtill ställs krav på avlagd kandidatexamen, konstnärlig kandidatexamen, yrkesexamen om minst 180 högskolepoäng eller motsvarande utländsk examen.

Mål

Kunskap och förståelse
För masterexamen skall studenten
– visa kunskap och förståelse inom huvudområdet för utbildningen, inbegripet såväl brett kunnande inom området som väsentligt fördjupade kunskaper inom vissa delar av området samt fördjupad insikt i aktuellt forsknings och utvecklingsarbete, och
– visa fördjupad metodkunskap inom huvudområdet för utbildningen.

Färdighet och förmåga
För masterexamen skall studenten
– visa förmåga att kritiskt och systematiskt integrera kunskap och att analysera, bedöma och hantera komplexa företeelser, frågeställningar och situationer även med begränsad information,
– visa förmåga att kritiskt, självständigt och kreativt identifiera och formulera frågeställningar, att planera och med adekvata metoder genomföra kvalificerade uppgifter inom givna tidsramar och därigenom bidra till kunskapsutvecklingen samt att utvärdera detta arbete,
– visa förmåga att i såväl nationella som internationella sammanhang muntligt och skriftligt klart redogöra för och diskutera sina slutsatser och den kunskap och de argument som ligger till grund för dessa i dialog med olika grupper, och
– visa sådan färdighet som fordras för att delta i forsknings- och utvecklingsarbete eller för att självständigt arbeta i annan kvalificerad verksamhet.

Värderingsförmåga och förhållningssätt
För masterexamen skall studenten
– visa förmåga att inom huvudområdet för utbildningen göra bedömningar med hänsyn till relevanta vetenskapliga, samhälleliga och etiska aspekter samt visa medvetenhet om etiska aspekter på forsknings- och utvecklingsarbete,
– visa insikt om vetenskapens möjligheter och begränsningar, dess roll i samhället och människors ansvar för hur den används, och
– visa förmåga att identifiera sitt behov av ytterligare kunskap och att ta ansvar för sin kunskapsutveckling.

Självständigt arbete (examensarbete)
För masterexamen skall studenten inom ramen för kursfordringarna ha fullgjort ett självständigt arbete (examensarbete) om minst 30 högskolepoäng inom huvudområdet för utbildningen. Det självständiga arbetet får omfatta mindre än 30 högskolepoäng, dock minst 15 högskolepoäng, om studenten redan har fullgjort ett självständigt arbete på avancerad nivå om minst 15 högskolepoäng inom huvudområdet för utbildningen eller motsvarande från utländsk utbildning.

Övrigt
För masterexamen med en viss inriktning skall också de preciserade krav gälla som varje högskola själv bestämmer inom ramen för kraven i denna examensbeskrivning.

Kandidatexamen

Omfattning
Kandidatexamen uppnås efter att studenten fullgjort kursfordringar om 180 högskolepoäng med viss inriktning som varje högskola själv bestämmer, varav minst 90 högskolepoäng med successiv fördjupning inom det huvudsakliga området (huvudområdet) för utbildningen.

Mål

Kunskap och förståelse
För kandidatexamen skall studenten
– visa kunskap och förståelse inom huvudområdet för utbildningen, inbegripet kunskap om områdets vetenskapliga grund, kunskap om tillämpliga metoder inom området, fördjupning inom någon del av området samt orientering om aktuella forskningsfrågor.

Färdighet och förmåga
För kandidatexamen skall studenten
– visa förmåga att söka, samla, värdera och kritiskt tolka relevant information i en problemställning samt att kritiskt diskutera företeelser, frågeställningar och situationer,
– visa förmåga att självständigt identifiera, formulera och lösa problem samt att genomföra uppgifter inom givna tidsramar,
– visa förmåga att muntligt och skriftligt redogöra för och diskutera information, problem och lösningar i dialog med olika grupper, och
– visa sådan färdighet som fordras för att självständigt arbeta inom det område som utbildningen avser.

Värderingsförmåga och förhållningssätt
För kandidatexamen skall studenten
– visa förmåga att inom huvudområdet för utbildningen göra bedömningar med hänsyn till relevanta vetenskapliga, samhälleliga och etiska aspekter,
– visa insikt om kunskapens roll i samhället och om människors ansvar för hur den används, och
– visa förmåga att identifiera sitt behov av ytterligare kunskap och att utveckla sin kompetens.

Självständigt arbete (examensarbete)
För kandidatexamen skall studenten inom ramen för kursfordringarna ha fullgjort ett självständigt arbete (examensarbete) om minst 15 högskolepoäng inom huvudområdet för utbildningen.

Övrigt
För kandidatexamen med en viss inriktning skall också de preciserade krav gälla som varje högskola själv bestämmer inom ramen för kraven i denna examensbeskrivning.

Arkitektexamen

Omfattning
Arkitektexamen uppnås efter att studenten fullgjort kursfordringar om 300 högskolepoäng.

Mål
För arkitektexamen skall studenten visa sådan kunskap och förmåga som krävs för att självständigt arbeta som arkitekt.

Kunskap och förståelse
För arkitektexamen skall studenten
– visa kunskap om områdets vetenskapliga och konstnärliga grund och insikt i relevant forsknings- och utvecklingsarbete, och
– visa såväl brett kunnande om och förståelse av arkitekturens teori och historia som fördjupad kunskap om arkitektonisk gestaltning, planering och utveckling av bebyggelsemiljöer samt de processer, metoder och författningar som påverkar dessa.

Färdighet och förmåga
För arkitektexamen skall studenten
– visa förmåga att med helhetssyn och i komplexa sammanhang planera, gestalta, vårda och förnya bebyggelsemiljöer och byggnader med hänsyn till olika krav, särskilt samhällets mål för hållbar utveckling,
– visa förmåga att med adekvat arkitektonisk metod och syntes kritiskt, självständigt och kreativt genomföra och utvärdera kvalificerade och skapande uppgifter inom givna ramar inom arkitekturens och samhällsbyggandets område,
– visa förmåga att tillämpa kunskap om fysikaliska förhållanden och tekniska principer för uppförande och förändringar av byggnadsverk,
– visa förmåga till lagarbete och samverkan i grupper med olika sammansättning, och
– visa förmåga att i såväl nationella som internationella sammanhang i bild och modell muntligt, skriftligt och på annat sätt i dialog med olika grupper klart redogöra för och diskutera sina slutsatser och den kunskap och de argument som ligger till grund för slutsatserna och därmed bidra till yrket och verksamheten.

Värderingsförmåga och förhållningssätt
För arkitektexamen skall studenten
– visa förmåga att med helhetssyn väga in relevanta vetenskapliga, samhälleliga, estetiska och etiska aspekter i sina bedömningar och avvägningar och samtidigt ta hänsyn till samhällets och alla människors olika behov och funktionsförmåga, liksom till samspelet mellan människor och den fysiska livsmiljön, inbegripet arbetsmiljön,
– visa förutsättningar att basera sitt arbete på kravet på långsiktiga och funktionella lösningar av hög kvalitet och med god gestaltning, och
– visa förmåga att identifiera sitt behov av ytterligare kunskap och att fortlöpande utveckla sin kompetens.

Självständigt arbete (examensarbete)
För arkitektexamen skall studenten inom ramen för kursfordringarna ha fullgjort ett självständigt arbete (examensarbete) om minst 30 högskolepoäng.

Övrigt
För arkitektexamen skall också de preciserade krav gälla som varje högskola själv bestämmer inom ramen för kraven i denna examensbeskrivning.

KNOTS

Excerpt from an interview with student in a project course

Student: When it comes to learning, you have to relate it to something concrete. Like when I teach how to make knots [in the navy]. You get a meter of clean white flag line, you tie your knot on it. It turns out just fine, and you can put it on a table. *Usually this is all you ever do, and you put 15 different advanced knots on display*.
But instead, when they have tied the knot, I say that they should also be able to use it for something. Like if you have to tie it to a very thick chain, that is like tying it to the leg of your chair, so I tell them to do that now! And they just stare, open-mouthed with surprise: "But I don't have the leg in my hand, so I can't tie the knot".
So instead of teaching them all 15 knots, I teach them four, the four most common, the most important. But they must *know in what situations a knot is appropriate, and use them in every possible way,* from front or behind, upside-down, in the dark, with one hand... They become capable, and directly they start – in the evenings: "hey, we heard about another knot...", and then you take it from there.
If I can't relate to my knowledge and understand what it can be used for, then I think it is worthless.

[...]

Kristina: [Here, in the project course,] how was it to apply knowledge from previous courses?

Student: Well.... but I think there are a lot [of students] who feel that we haven't used much knowledge from past courses. Because this is not like the exam tasks, it's not extremely difficult. We are building this thing in different parts and assembling them, and they think it's just carpentry. But, as I see it, it takes quite advanced Machine Elements now and then. Because how do these function together? And it's... [...].

Kristina: But it is difficult to recognise the knowledge, you mean?

Student: Yes! Because this isn't... err...

Kristina: Like in your example, in the course you have only learned how to tie knots with flag line. But here you have to tie it around a thick chain, and then you think you have no use for that which you learned in the course?

Student: Yes, exactly. Because *here it is just a common knot, but applied in a difficult way*. In the previous course I had to tie a lot of difficult knots, but I never had the opportunity to use them.

[My approximate translation, my italics / Kristina]

5 criteria for objectives

Objectives should:

1. state the intended learning outcomes
   – Do they state what the student should be able to do as a result of the course?

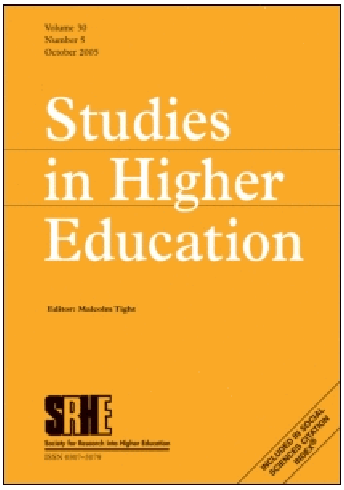
2. in terms of observable performances,
   – Do they express active performance (as opposed to understand, be familiar with etc)?
   – Are they clear and specific enough for assessment to be based upon them?
   – Would the student herself know if she has reached them?

3. hinting at the level of understanding.
   – Use a taxonomy to detect over-emphasis on low-level objectives.
   – Is focus on working knowledge?

And also:

4. explicitly show the course's contribution to the programme as a whole (see the degree ordinance),

5. and be realistic with regards to student time and other resources.



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Formative assessment and self-regulated learning: a model and seven principles of good feedback practice

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Formative assessment and self-regulated learning: a model and seven principles of good feedback practice

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The research on formative assessment and feedback is reinterpreted to show how these processes can help students take control of their own learning, i.e. become self-regulated learners. This reformulation is used to identify seven principles of good feedback practice that support self-regulation. A key argument is that students are already assessing their own work and generating their own feedback, and that higher education should build on this ability. The research underpinning each feedback principle is presented, and some examples of easy-to-implement feedback strategies are briefly described. This shift in focus, whereby students are seen as having a proactive rather than a reactive role in generating and using feedback, has profound implications for the way in which teachers organise assessments and support learning.

Introduction

This article positions the research on formative assessment and feedback within a model of self-regulated learning. Formative assessment refers to assessment that is specifically intended to generate feedback on performance to improve and accelerate learning (Sadler, 1998). A central argument is that, in higher education, formative assessment and feedback should be used to empower students as self-regulated learners. The construct of self-regulation refers to the degree to which students can regulate aspects of their thinking, motivation and behaviour during learning (Pintrich & Zusho, 2002). In practice, self-regulation is manifested in the active monitoring and regulation of a number of different learning processes, e.g. the setting of, and orientation towards, learning goals; the strategies used to achieve goals; the management of resources; the effort exerted; reactions to external feedback; the products produced.

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Intelligent self-regulation requires that the student has in mind some goals to be achieved against which performance can be compared and assessed. In academic settings, specific targets, criteria, standards and other external reference points (e.g. exemplars) help define goals. Feedback is information about how the student's present state (of learning and performance) relates to these goals and standards. Students generate internal feedback as they monitor their engagement with learning activities and tasks, and assess progress towards goals. Those more effective at self-regulation, however, produce better feedback or are more able to use the feedback they generate to achieve their desired goals (Butler & Winne, 1995). Self-regulated learners also actively interpret external feedback, for example, from teachers and other students, in relation to their internal goals. Although research shows that students can learn to be more self-regulated (see Pintrich, 1995; Zimmerman & Schunk, 2001), how to enhance feedback (both self-generated and external) in support of self-regulation has not been fully explored in the current literature. This article helps to address this gap by proposing seven principles of good feedback practice in relation to the development of self-regulation.

The rationale for rethinking formative assessment and feedback

Over the last two decades, there has been a shift in the way teachers and researchers write about student learning in higher education. Instead of characterising it as a simple acquisition process based on teacher transmission, learning is now more commonly conceptualised as a process whereby students actively construct their own knowledge and skills (Barr & Tagg, 1995; DeCorte, 1996; Nicol, 1997). Students interact with subject content, transforming and discussing it with others, in order to internalise meaning and make connections with what is already known. Terms like 'student-centred learning', which have entered the lexicon of higher education, are one reflection of this new way of thinking. Even though there is disagreement over the precise definition of student-centred learning, the core assumptions are active engagement in learning and learner responsibility for the management of learning (Lea *et al.*, 2003).

Despite this shift in conceptions of teaching and learning, a parallel shift in relation to formative assessment and feedback has been slower to emerge. In higher education, formative assessment and feedback are still largely controlled by and seen as the responsibility of teachers; and feedback is still generally conceptualised as a transmission process, even though some influential researchers have recently challenged this viewpoint (Sadler, 1998; Boud, 2000; Yorke, 2003). Teachers 'transmit' feedback messages to students about what is right and wrong in their academic work, about its strengths and weaknesses, and students use this information to make subsequent improvements.

There are a number of problems with this transmission view when applied to formative assessment and feedback. Firstly, if formative assessment is exclusively in the hands of teachers, then it is difficult to see how students can become empowered and develop the self-regulation skills needed to prepare them for learning outside university and throughout life (Boud, 2000). Secondly, there is an assumption that when teachers transmit feedback information to students these messages are easily decoded and translated into action. Yet, there is strong evidence that feedback messages are invariably complex and difficult to decipher, and that students require opportunities to construct actively an understanding of them (e.g. through discussion) before they can be used to regulate performance (Ivanic *et al.*, 2000; Higgins *et al.*, 2001). Thirdly, viewing feedback as a cognitive process involving only transfer of information ignores the way feedback interacts with motivation and beliefs. Research shows that feedback both regulates and is regulated by motivational beliefs. External feedback has been shown to influence how students feel about themselves (positively or negatively), and what and how they learn (Dweck, 1999). Research also shows (Garcia, 1995) that beliefs can regulate the effects of feedback messages (e.g. perceptions of self-efficacy might be maintained by reinterpreting the causes of failure). Fourthly, as a result of this transmission view of feedback, the workload of teachers in higher education increases year by year as student numbers and class sizes become larger. One way of addressing this issue is to re-examine the nature of feedback, and who provides it (e.g. teacher, peer, self), in relation to its effectiveness in supporting learning processes.

In the next section a conceptual model of formative assessment and feedback is presented that centres on the processes inherent in learner self-regulation. A key feature of the model that differentiates it from everyday understandings of feedback is that students are assumed to occupy a central and active role in all feedback processes. They are always actively involved in monitoring and regulating their own performance, both in relation to desired goals and in terms of the strategies used to reach these goals. The student also actively constructs his or her own understanding of feedback messages derived from external sources (Black & Wiliam, 1998; Ivanic *et al.*, 2000). This is consistent with the literature on student-centred and social constructivist conceptions of learning (Palinscar, 1998; Lea *et al.*, 2003).

The conceptual model of self-regulation outlined in this article draws on earlier work by Butler and Winne (1995). Their article stands out as one of the few available to provide a theoretical synthesis of thinking about feedback and self-regulation. Following a presentation of the conceptual model, seven principles of good feedback practice are proposed; these are aligned to the model and backed up by a review of the research literature on assessment and feedback. Relating the recent feedback research to the conceptual model adds significant value to this area of study. First, the model provides a coherent educational rationale to draw together some quite diverse research findings on formative assessment and feedback. Second, the model and seven principles offer complementary tools that teachers might use to think about the design and evaluation of their own feedback procedures. In that context, after describing each principle we identify some related feedback strategies that teachers might easily implement.

A conceptual model of processes of self-regulation and internal feedback

Figure 1 presents a conceptual model of self-regulation and feedback that synthesises current thinking in these areas. The top part of Figure 1 is based on a model originally published by Butler and Winne (1995). Processes internal to the learner are depicted inside the shaded area. This shows how the learner monitors and regulates learning and performance. It also shows the crucial role of internally generated feedback in these processes. Pintrich and Zusho (2002) provide the following working definition of self-regulation:

> Self-regulated learning is an active constructive process whereby learners set goals for their learning and monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features of the environment. (p. 64)

This definition fits the purpose of this article in that it recognises that self-regulation applies not just to cognition but also to motivational beliefs and overt behaviour. It also recognises that there are limits to learner self-regulation; for example, the teacher usually devises the learning task and determines the assessment requirements.

In the model, an academic task set by the teacher (A) in class, or set as an assignment, is shown as the trigger to initiate self-regulatory processes in the student (shown at the centre of the diagram). Engagement with the task requires that the student draw on prior knowledge and motivational beliefs (B), and construct a personal interpretation of the meaning of the task and its requirements. Based on this internal conception, the student formulates his or her own task goals (C). While there would normally be an overlap between the student's goals and those of the teacher, the degree of overlap may not be high (e.g. if the student wishes only to pass the assignment). The student's goals might also be fuzzy rather than clear (e.g. a vague intention or task orientation). Nonetheless, these goals would help shape the strategies and tactics (D) that are used by students to generate outcomes, both internal (E) and externally observable (F). Internal outcomes refer to changes in cognitive or affective/motivational states that occur during task engagement (e.g. increased understanding, changes in self-perceptions of ability). Externally observable outcomes refer to tangible products produced (e.g. essays) and behaviours (e.g. student presentations).

Monitoring these interactions with the task, and the outcomes that are being cumulatively produced, generates *internal feedback* at a variety of levels (i.e. cognitive, motivational and behavioural). This feedback is derived from a comparison of current progress against desired goals. It is these comparisons that help the student determine whether current modes of engagement should continue as is, or if some type of change is necessary. For example, this self-generated feedback might lead to a reinterpretation of the task, or to an adjustment of internal goals, tactics and strategies. The student might even revise his or her domain knowledge or motivational beliefs which, in turn, might influence subsequent self-regulation.

In the model, external feedback to the student (G) might be provided by the teacher, by a peer or by other means (e.g. a placement supervisor, a computer). This additional information might augment, concur or conflict with the student's interpretation of the task and the path of learning. However, to produce an effect on internal processes or external outcomes the student must actively engage with these external inputs. In effect, the teachers' feedback responses would have to be interpreted,

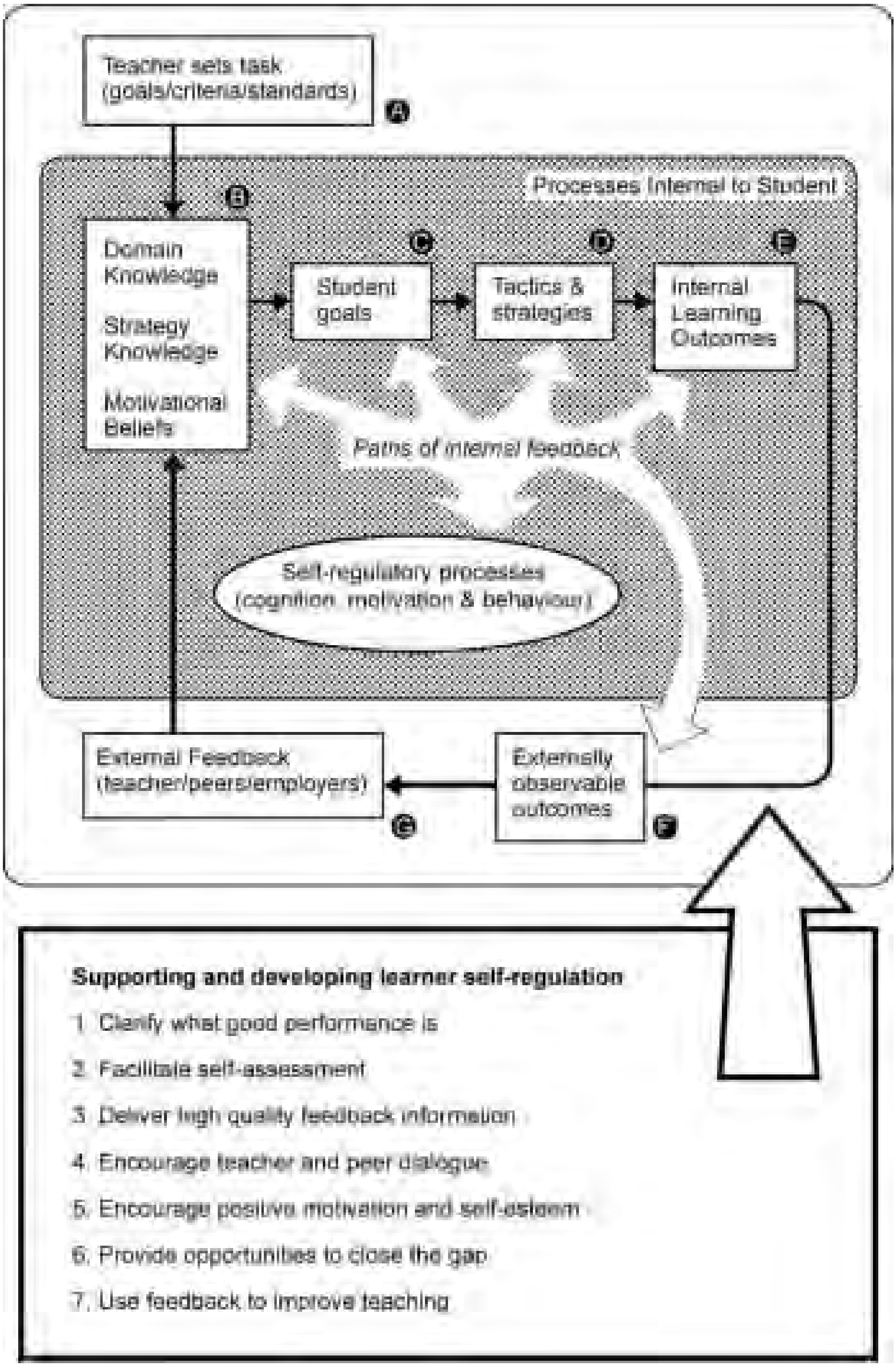

Figure 1. A model of self-regulated learning and the feedback principles that support and develop self-regulation in students

constructed and internalised by the student if they were to have a significant influence on subsequent learning (Ivanic *et al.*, 2000).

Some supporting research

There is considerable research evidence to show that effective feedback leads to learning gains. Black and Wiliam (1998) drew together over 250 studies of feedback carried out since 1988, spanning all educational sectors. These studies focused on real teaching situations, and the selection included teacher-made assessments and self and peer assessments. A meta-analysis of these studies revealed that feedback produced significant benefits in learning and achievement across all content areas, knowledge and skill types, and levels of education. While the bulk of Black and Wiliam's data came from the school sector, their review and that of others (e.g. Hattie, 1987; Crooks, 1988), provides convincing evidence of the value of feedback in promoting learning. In addition, there is a large body of complementary research studies demonstrating the effects of self and peer feedback on learning (e.g. Boud, 1995; Boud *et al.*, 1999). Nonetheless, while the work of Black and others has had an important influence on teaching practices in schools (Black *et al.*, 2003) it has so far had much less influence on higher education.

One of the most influential articles underpinning the Black and Wiliam review, and the writings of other researchers (e.g. Yorke, 2003), is that of Sadler (1989). Sadler identified three conditions necessary for students to benefit from feedback in academic tasks. He argued that the student must know:

1. what good performance is (i.e. the student must possess a concept of the goal or standard being aimed for);
2. how current performance relates to good performance (for this, the student must be able to compare current and good performance);
3. how to act to close the gap between current and good performance.

From this analysis Sadler made an important observation: for students to be able to *compare* actual performance with a standard (as suggested by 2), and take action to close the gap (3), then they must already possess some of the same evaluative skills as their teacher (Sadler, 1989). For some writers, this observation has led to the conclusion that, as well as improving the quality of feedback messages, teachers should focus much more effort on strengthening the skills of self-assessment in their students (Boud, 2000; Yorke, 2003). Sadler's argument, that students are already generating their own feedback, also helps account for the common finding that students still make significant progress in their learning even when the external feedback they receive is quite impoverished (especially in many large enrolment classes).

Although Sadler's writings are consistent with the argument in this article, his focus on 'control theory and closing gaps' has been interpreted by some as too limited a basis to account for the range of effects produced by feedback (Gibbs, 2004). This article addresses this concern by repositioning formative assessment and feedback within a wider framework that encompasses self-regulation of motivation and behaviour as well as of cognition. For example, feedback is involved when students actively control their study time or their interactions with others (behaviour), and when they monitor and control motivational beliefs to adapt to the demands of the course (e.g. choosing a personal goal orientation).

Despite the appeal of self-regulation as a construct, it is important to recognise some basic assumptions underlying its use. While it is assumed that students can self-regulate internal states and behaviour as well as some aspects of the environment, this does not mean that the student always has full control. Learning tasks set by teachers, marking regimes and other course requirements are not under students' control, even though students still have latitude to self-regulate within such constraints. Also, students often learn in implicit or unintentional ways without explicit regulation (e.g. aspects of some skills such as reading are automated).

There is a large body of empirical evidence, mainly published in the USA, showing that learners who are more self-regulated are more effective learners: they are more persistent, resourceful, confident and higher achievers (Pintrich, 1995; Zimmerman & Schunk, 2001). Also, the more learning becomes self-regulated, the more students assume control over their learning, and the less dependent they are on external teacher support when they engage in regulatory activities (Zimmerman & Schunk, 2004). Importantly, this research also shows that any student, even those 'at risk', can learn to become more self-regulating (Pintrich & Zusho, 2002). The development of self-regulation in students can be facilitated by structuring learning environments in ways that make learning processes explicit, through meta-cognitive training, self-monitoring and by providing opportunities to practise self-regulation (Schunk & Zimmerman, 1994; Pintrich, 1995). The contribution of this article is to identify how formative assessment and feedback processes might help foster self-regulation (it is beyond the scope of this article to summarise the literature on self-regulation but a useful first text might be that by Zimmerman and Schunk, 2001).

Seven principles of good feedback practice: facilitating self-regulation

From the self-regulation model and the research literature on formative assessment it is possible to identify some principles of good feedback practice. These are shown at the bottom of Figure 1. Good feedback practice is broadly defined here as anything that might strengthen the students' capacity to self-regulate their own performance. A synthesis of the research literature led to the following seven principles:

Good feedback practice:

1. helps clarify what good performance is (goals, criteria, expected standards);
2. facilitates the development of self-assessment (reflection) in learning;
3. delivers high quality information to students about their learning;
4. encourages teacher and peer dialogue around learning;
5. encourages positive motivational beliefs and self-esteem;
6. provides opportunities to close the gap between current and desired performance;
7. provides information to teachers that can be used to help shape teaching.

The following sections provide the rationale for each principle in terms of the self-regulation and the associated research literature. Specific strategies that teachers can use to facilitate self-regulation are proposed after the presentation of each principle.

1. Helps clarify what good performance is

Students can only achieve learning goals if they understand those goals, assume some ownership of them, and can assess progress (Sadler, 1989; Black & Wiliam, 1998). In academic settings, understanding goals means that there must be a reasonable degree of overlap between the task goals set by students and the goals originally set by the teacher. This is logically essential, given that it is the students' goals that serve as the criteria for self-regulation (Figure 1). However, there is considerable research evidence showing significant mismatches between tutors' and students' conceptions of goals, and of assessment criteria and standards.

Hounsell (1997) has shown that tutors and students often have quite different conceptions about the goals and criteria for essays in undergraduate courses in history and psychology, and that poor essay performance is correlated with the degree of mismatch. In a similar vein, Norton (1990) has shown that, when students were asked to rank specific assessment criteria for an essay task, they produced quite different rankings from those of their teachers, emphasising content above critical thinking and argument. Weak and incorrect conceptions of goals not only influence what students do, but also the value of external feedback information. If students do not share (at least in part) their teacher's conceptions of assessment goals (and criteria and standards), then the feedback information they receive is unlikely to 'connect' (Hounsell, 1997). In this case, it will be difficult for students to evaluate discrepancies between required and actual performance. It is also important to note here that feedback not only has a role in helping guide students towards academic goals, but, over time, it also has a role in helping clarify what these goals are (Sadler, 1989).

One way of clarifying task requirements (goals/criteria/standards) is to provide students with written documents containing statements that describe assessment criteria and/or the standards that define different levels of achievement. However, many studies have shown that it is difficult to make assessment criteria and standards explicit through written documentation or through verbal descriptions in class (Rust *et al.*, 2003). Most criteria for academic tasks are complex, multidimensional (Sadler, 1989) and difficult to articulate; they are often 'tacit' and unarticulated in the mind of the teacher. As Yorke (2003, p. 480) notes:

> Statements of expected standards, curriculum objectives or learning outcomes are generally insufficient to convey the richness of meaning that is wrapped up in them.

Hence there is a need for strategies that complement written materials and simple verbal explanations. An approach that has proved particularly powerful in clarifying goals and standards has been to provide students with 'exemplars' of performance (Orsmond *et al.*, 2002). Exemplars are effective because they make explicit what is required, and they define a valid standard against which students can compare their work.

Other strategies that have proved effective in clarifying criteria, standards and goals include: (i) providing better definitions of requirements using carefully constructed criteria sheets and performance-level definitions; (ii) increasing discussion and reflection about criteria and standards in class (e.g. before an assignment); (iii) involving students in assessment exercises where they mark or comment on other students' work in relation to defined criteria and standards; (iv) workshops where students in collaboration with the teacher devise or negotiate their own assessment criteria for a piece of work. These strategies exemplify increasing levels of self-regulation.

2. Facilitates the development of self-assessment (reflection) in learning

As suggested earlier, one effective way to develop self-regulation in students is to provide them with opportunities to practise regulating aspects of their own learning and to reflect on that practice. Students are (to some extent) already engaged in monitoring gaps between internally set task goals and the outcomes that they are generating (both internal and external). This monitoring is a by-product of purposeful engagement in a task (Figure 1). However, in order to build on this, and to develop systematically the learner's capacity for self-regulation, teachers need to create more structured opportunities for self-monitoring and the judging of progression to goals. Self-assessment tasks are an effective way of achieving this, as are activities that encourage reflection on learning progress.

Over the last decade there has been an increasing interest in self-assessment in higher education (Boud, 1995). Research shows that, when suitably organised, self-assessment can lead to significant enhancements in learning and achievement. For example, McDonald and Boud (2003) have shown that training in self-assessment can improve students' performance in final examinations. Also, Taras (2001, 2002, 2003) has carried out a number of studies on student self-assessment in higher education which have shown positive benefits. In one study, students were trained in self-assessment under two conditions: self-assessment prior to peer and tutor feedback and self-assessment with integrated tutor feedback. The latter condition involved students self-assessing after they had received tutor feedback. The results showed that, while both conditions benefited learning, self-assessment with integrated tutor feedback helped students identify and correct more errors (those that they or peers had not been aware of) than self-assessment prior to peer or tutor feedback. Interestingly, this study not only shows the benefits of integrating external and internal feedback, but also ways of helping students internalise and use tutor feedback.

In developing self-assessment skills it is important to engage students in both identifying standards/criteria that will apply to their work (discussed in principle 1 above), and in making judgements about how their work relates to these standards (Boud, 1986). While structured opportunities for training in self-assessment are important, there are other ways of supporting the development of these skills. One approach is to provide students with opportunities to evaluate and provide feedback on each other's work. Such peer processes help develop the skills needed to make objective judgements against standards, skills which are transferred when students turn to producing and regulating their own work (Boud *et al.*, 1999; Gibbs, 1999). Another approach is to create frequent opportunities for reflection by students during their study. Cowan (1999) identifies ways that this can be done, both in the context of simple classroom activities and during longer-term projects.

Other examples of structured reflection and self-assessment are varied and might include students: (i) requesting the kinds of feedback they would like when they hand in work; (ii) identifying the strengths and weaknesses in their own work in relation to criteria or standards before handing it in for teacher feedback; (iii) reflecting on their achievements and selecting work in order to compile a portfolio; (iv) reflecting before a task on achievement milestones and reflecting back on progress and forward to the next stage of action (Cowan, 1999).

3. Delivers high quality information to students about their learning

While research shows that teachers have a central role in developing their students' own capacity for self-regulation, they are also a crucial source of external feedback. Feedback from teachers is a source against which students can evaluate progress, and check out their own internal constructions of goals, criteria and standards. Moreover, teachers are much more effective in identifying errors or misconceptions in students' work than peers or the students themselves. In effect, feedback from teachers can help substantiate student self-regulation.

In the research literature there is little consensus about what constitutes good quality external feedback. Quality is defined quite broadly, and tends to be discussed in relation to student needs and teacher-defined goals. For example, most researchers and textbook writers (e.g. Freeman & Lewis, 1998) are concerned that feedback to students might be delayed, not relevant or informative, that it might focus on low-level learning goals or might be overwhelming in quantity or deficient in tone (i.e. too critical). For these researchers, the way forward is to ensure that feedback is provided in a timely manner (close to the act of learning production), that it focuses not just on strengths and weaknesses but also on offering corrective advice, that it directs students to higher order learning goals, and that it involves some praise alongside constructive criticism. While each of these issues is important, there is a need for a more focused definition of quality in relation to external feedback, a definition that links more closely to the idea of self-regulation. Hence it is proposed here that:

- Good quality external feedback is information that helps students troubleshoot their own performance and self-correct: that is, it helps students take action to reduce the discrepancy between their intentions and the resulting effects.

In this context, it is argued that, where feedback is given, it is important that it is related to (and that students understand its relation to) goals, standards or criteria. Moreover, from this definition it is clear that external feedback should also help convey to students an appropriate conception of the goal. This is not always the case. For example, it has become common practice in recent years to devise feedback sheets with assessment criteria, as a way of informing students about task requirements and of providing consistent feedback in relation to goals (where there are a number of assessors). However, Sadler (1983) has argued that the use of criteria sheets often has unwanted effects in relation to essay assessments: for example, if there are a large number of criteria (12–20), this may convey to the student a conception of the essay as a list of things to be done (ticked off) rather than as a holistic process (e.g. involving the production of a coherent argument supported by evidence). So, as well as relating feedback to criteria and goals, teachers should also be aware that the instruments they use to deliver feedback might adversely influence students' conceptions of the expected goals.

In the literature on essay assessment, some researchers have tried to formulate guidelines regarding the quantity and tone of feedback comments that, when analysed, show a close correspondence with the principle underlying the above definition of feedback quality. For example, Lunsford (1997) examined the written feedback comments given by writing experts on students' essays. From his analysis he made two proposals: firstly, that three well-thought-out feedback comments per essay was the optimum if the expectation was that students would act on these comments; and secondly, and more importantly, these comments should indicate to the student how the reader (the teacher) experienced the essay as it was read (i.e. playing back to the students how the essay worked), rather than offer judgemental comments. Such comments would help the student grasp the difference between his or her intentions (goals) and the effects of the writing. Lunsford also advises that the comments should always be written in a non-authoritative tone, and where possible they should offer corrective advice (both about the writing process as well as about content) instead of just information about strengths and weaknesses. In relation to self-regulation, Lunsford's reader-response strategy supports the shift from feedback provided by the teacher to students' evaluating their own writing.

The literature on external feedback is undeveloped in terms of how teachers should frame feedback comments, what kind of discourse should be used, how many comments are appropriate and in what context they should be made. Much more research is required in this area. One fruitful area of investigation is that currently being conducted by Gibbs and Simpson (2004) on the relationship between feedback and the time students spend on task. They have shown that if students receive feedback often and regularly, it enables better monitoring and self-regulation of progress by students. Other research is investigating the strengths of alternative modes of feedback communication (e.g. audio feedback, computer feedback) and of alternative ways of producing feedback information (e.g. poster productions where students get feedback by comparing their work with that of other students) (Hounsell & McCune, 2003; Hounsell, 2004).

Further strategies that increase the quality of teacher feedback based on the definition given above and on other research include: (i) making sure that feedback is provided in relation to pre-defined criteria but paying particular attention to the number of criteria; (ii) providing timely feedback—this means before it is too late for students to change their work (i.e. before submission) rather than just, as the research literature often suggests, soon after submission; (iii) providing corrective advice, not just information on strengths/weaknesses; (iv) limiting the amount of feedback so that it is actually used; (v) prioritising areas for improvement; (vi) providing online tests so that feedback can be accessed anytime, any place and as many times as students wish.

4. Encourages teacher and peer dialogue around learning

In the self-regulation model, for external feedback to be effective it must be understood and internalised by the student before it can be used to make productive improvements. Yet in the research literature (Chanock, 2000; Hyland, 2000) there is a great deal of evidence that students do not understand the feedback given by tutors (e.g. 'this essay is not sufficiently analytical'), and are therefore not be able to take action to reduce the discrepancy between their intentions (goals) and the effects they would like to produce (i.e. the student may not know what to do to make the essay 'more analytical'). External feedback as a transmission process involving 'telling' ignores the active role the student must play in constructing meaning from feedback messages, and of using this to regulate performance.

One way of increasing the effectiveness of external feedback, and the likelihood that the information provided is understood by students, is to conceptualise feedback more as *dialogue* rather than as information transmission. Feedback as dialogue means that the student not only receives initial feedback information, but also has the opportunity to engage the teacher in discussion about that feedback. Some researchers maintain that teacher–student dialogue is essential if feedback is to be effective in higher education (Laurillard, 2002). Freeman and Lewis (1998) argue that the teacher 'should try to stimulate a response and a continuing dialogue—whether this be on the topics that formed the basis of the assignment or aspects of students' performance or the feedback itself' (p. 51). Discussions with the teacher help students to develop their understanding of expectations and standards, to check out and correct misunderstandings and to get an immediate response to difficulties.

Unfortunately, with large class sizes it can be difficult for the teacher to engage in dialogue with students. Nonetheless, there are ways that teachers might increase feedback dialogue even in these situations. One approach is to structure small group break-out discussions of feedback in class, after students have received written comments on their individual assignments. Another approach is to use classroom technologies. These technologies help collate student responses to in-class questions (often multiple-choice questions) using handset devices. The results are fed back to the class visually as a histogram. This collated feedback has been used as a trigger for peer discussion (e.g. 'convince your neighbour that you have the right answer') and teacher-managed discussion in large classes (e.g. Boyle & Nicol, 2003; Nicol & Boyle, 2003).

These studies identify another source of external feedback to students—their peers. Peer dialogue enhances in students a sense of self-control over learning in a variety of ways. Firstly, students who have just learned something are often better able than teachers to explain it to their classmates in a language and in a way that is accessible. Secondly, peer discussion exposes students to alternative perspectives on problems and to alternative tactics and strategies. Alternative perspectives enable students to revise or reject their initial hypothesis, and construct new knowledge and meaning through negotiation. Thirdly, by commenting on the work of peers, students develop detachment of judgement (about work in relation to standards), which is transferred to the assessment of their own work (e.g. 'I didn't do that either'). Fourthly, peer discussion can be motivational in that it encourages students to persist (see Boyle & Nicol, 2003). Finally, it is sometimes easier for students to accept critiques of their work from peers rather than tutors.

Dialogical feedback strategies that support self-regulation include: (i) providing feedback using one-minute papers in class (see Angelo & Cross, 1993); (ii) reviewing feedback in tutorials, where students are asked to read the feedback comments they have been given earlier on an assignment, and discuss these with peers (they might also be asked to suggest strategies to improve performance next time); (iii) asking students to find one or two examples of feedback comments that they found useful and to explain how they helped; (iv) having students give each other descriptive feedback on their work in relation to published criteria before submission; (iv) group projects, especially where students discuss criteria and standards before the project begins.

5. Encourages positive motivational beliefs and self-esteem

Motivation and self-esteem play a very important role in learning and assessment, as is shown in Figure 1. Studies by Dweck (1999) show that, depending on their beliefs about learning, students possess qualitatively different motivational frameworks. These frameworks affect both students' responses to external feedback and their commitment to the self-regulation of learning.

Research in school settings has shown that frequent high-stakes assessment (where marks or grades are given) has a 'negative impact on motivation for learning that militates against preparation for lifelong learning' (Harlen & Crick, 2003). Dweck (1999) argues that such assessments encourage students to focus on performance goals (passing the test, looking good) rather than learning goals (mastering the subject). In one study, Butler (1988) demonstrated that feedback comments alone increased students' subsequent interest in learning when compared with two other controlled situations, one where only marks were given and the other where students were given feedback and marks. Butler argued that students paid less attention to the comments when given marks, and consequently did not try to use the comments to make improvements. This phenomenon is also commonly reported by academics in higher education.

Butler (1987) has also argued that grading student performance has less effect than feedback comments, because it leads students to compare themselves against others (ego-involvement) rather than to focus on the difficulties in the task and on making efforts to improve (task-involvement). Feedback given as grades has also been shown to have especially negative effects on the self-esteem of low-ability students (Craven *et al.*, 1991).

Dweck (1999) has interpreted these findings in terms of a developmental model that differentiates students into those who believe that ability is fixed, and that there is a limit to what they can achieve (the 'entity view'), and those that believe that their ability is malleable and depends on the effort that is input into a task (the 'incremental view'). These views affect how students respond to learning difficulties. Those with an entity view (fixed) interpret failure as a reflection of their low ability, and are likely to give up, whereas those with an incremental view (malleable) interpret this as a challenge or an obstacle to be overcome, and increase their effort. Grant and Dweck (2003) have confirmed the validity of this model within higher education, as have Yorke and Knight (2004), who found that about one-third of a sample of 2269 undergraduates students in first and final years, and across a range of disciplines, held beliefs in fixed intelligence.

Although this is an underexplored area of research, there is evidence that teachers can have a positive or negative effect on motivation and self-esteem. They can influence both the goals that students set (learning or performance goals), as well as their commitment to those goals. Praising effort and strategic behaviours, and focusing students through feedback on learning goals, leads to higher achievement than praising ability or intelligence. The latter can result in a learned-helplessness orientation (Dweck, 1999). As Black and Wiliam (1998) note, feedback that draws attention away from the task and towards self-esteem can have a negative effect on attitudes and performance. In other words, it is important that students understand that feedback is an evaluation, not of the person but of the performance in context. This holds true whether the feedback derives from an external source or is generated through self-assessment.

These studies on motivation and self-esteem are important—they help explain why students often fail to self-regulate. In terms of teaching practice they suggest that motivation and self-esteem are more likely to be enhanced when a course has many low-stakes assessment tasks, with feedback geared to providing information about progress and achievement, rather than high-stakes summative assessment tasks where information is only about success or failure, or about how students compare with their peers (e.g. grades). Other strategies that help encourage high levels of motivation and self-esteem include: (i) providing marks on written work only after students have responded to feedback comments (Gibbs, 1999); (ii) allocating time for students to rewrite selected pieces of work—this would help change students' expectations about purpose and learning goals; (iii) automated testing with feedback; (iv) drafts and resubmissions.

6. Provides opportunities to close the gap between current and desired performance

So far, feedback has been discussed from a cognitive or informational perspective, and from a motivational perspective. However, in terms of self-regulation we must also consider how feedback influences behaviour and the academic work that is produced. According to Yorke (2003), two questions might be asked regarding external feedback. First, is the feedback of the best quality, and second, does it lead to changes in student behaviour? Many writers have focused on the first question, but the second is equally important. External feedback provides an opportunity to close a gap between current performance and the performance expected by the teacher. As Boud notes:

> The only way to tell if learning results from feedback is for students to make some kind of response to complete the feedback loop (Sadler, 1989). This is one of the most often forgotten aspects of formative assessment. Unless students are able to use the feedback to produce improved work, through for example, re-doing the same assignment, neither they nor those giving the feedback will know that it has been effective. (Boud, 2000, p. 158)

In the self-regulation model (Figure 1), Boud's arguments about closing the performance gap might be viewed in two ways. First, closing the gap is about supporting students while engaged in the act of production of a piece of work (e.g. essays, presentations). Second, it is about providing opportunities to repeat the same 'task-performance–external feedback cycle' by, for example, allowing resubmission. External feedback should support both processes: it should help students to recognise the next steps in learning and how to take them, both during production and in relation to the next assignment.

Supporting the act of production requires the generation of concurrent or intrinsic feedback that students can interact with while engaged in an assessment task. This feedback would normally be built into the task (e.g. a group task with peer interaction, or a computer simulation), or the task might be broken down into components each associated with its own feedback. Many forms of electronic feedback (e.g. online simulations) can be automatically generated to support task engagement (Bull & McKenna, 2004). Providing feedback at sub-task level is not significantly different from other forms of feedback described in this article.

In higher education, most students have little opportunity to use directly the feedback they receive to close the performance gap, especially in the case of planned assignments. Invariably they move on to the next assessment task soon after feedback is received. While not all work can be resubmitted, many writers argue that resubmissions should play a more prominent role in learning (Boud, 2000). Also, greater emphasis might need to be given to providing feedback on work-in-progress (e.g. on structures for essays, plans for reports, sketches) and to encouraging students to plan the strategies they might use to improve subsequent work (Hounsell, 2004).

The following are some specific strategies to help students use external feedback to regulate and close the performance gap: (i) provide feedback on work in progress and increase opportunities for resubmission; (ii) introduce two-stage assignments where feedback on stage one helps improve stage two (Gibbs, 2004); (iii) teachers might model the strategies they would use to close a performance gap in class (e.g. model how to structure an essay when given a new question); (iv) specifically provide some 'action points' alongside the normal feedback provision; (v) involve students in groups in identifying their own action points in class after they have read the feedback on their assignments. The latter strategy would integrate feedback into the teaching and learning process, and involve the students more actively in the generation and planned use of feedback.

7. Provides information to teachers that can be used to help shape the teaching

Good feedback practice is not only about providing accessible and usable information that helps students improve their learning, but it is also about providing good information to teachers. As Yorke (2003, p. 482) notes:

> The act of assessing has an effect on the assessor as well as the student. Assessors learn about the extent to which they [students] have developed expertise and can tailor their teaching accordingly.

In order to produce feedback that is relevant and informative and meets students' needs, teachers themselves need good data about how students are progressing. They also need to be involved in reviewing and reflecting on this data, and in taking action to help support the development of self-regulation in their students.

In the self-regulation model (Figure 1) information about students only becomes available when the learning outcomes are translated into public performances and products. Teachers help generate this public information about students through a variety of methods—by setting assessment tasks, by questioning of students in class and by observing behaviour (e.g. presentations). Such information helps teachers uncover student difficulties with subject matter (e.g. conceptual misunderstandings) and study methods.

Frequent assessment tasks, especially diagnostic tests, can help teachers generate cumulative information about students' levels of understanding and skill, so that they can adapt their teaching accordingly. This is one of the key ideas behind the work in the USA of Angelo and Cross (1993). They have shown how teachers can gain regular feedback information about student learning within large classes by using variants of the one-minute paper—questions that are posed to students before a teaching session begins, and responded to at the end of the session (e.g. What was the most important argument in this lecture? What question remains uppermost in your mind now at the end of this teaching session?). These strategies can be adapted to any classroom situation or discipline. Moreover, they help develop in students important meta-cognitive skills such as the ability to think holistically and to identify gaps in understanding (Steadman, 1998).

As well as giving feedback to the teacher, one-minute papers can also be used to provide feedback to the student (e.g. when teachers replay some of the student responses to the one-minute paper in class at the next teaching session). Indeed, this approach allows teachers and students to share, on a regular basis, their conceptions about both the goals and processes of learning (Stefani & Nicol, 1997), thus supporting academic self-regulation.

Other strategies available to teachers to help generate and collate quality information about student learning include: (i) having students request the feedback they would like when they make an assignment submission (e.g. on a pro forma with published criteria); (ii) having students identify where they are having difficulties when they hand in assessed work; (iii) asking students in groups to identify 'a question worth asking', based on prior study, that they would like to explore for a short time at the beginning of the next tutorial.

Conclusion and future work

This article has argued that conceptions of assessment have lagged behind conceptions of learning in higher education. While students have been given more responsibility for learning in recent years, there has been far greater reluctance to give them increased responsibility for assessment processes (even low-stakes formative processes). Yet, if students are to be prepared for learning throughout life, they must be provided with opportunities to develop the capacity to regulate their own learning as they progress through higher education. This article has identified ways in which formative assessment and feedback might be organised so as to support this development. It has provided some key principles of good feedback practice that address a wide spectrum—the cognitive, behavioural and motivational aspects of self-regulation. How might teachers use the ideas in this article? One practical proposal is that teachers examine current assessment practices in relation to the self-regulation model and to the seven principles. An audit of this kind might help identify where assessment practices might be strengthened. However, the seven principles presented here do not exhaust all that teachers might do to enhance self-regulated learning in classrooms. They merely provide a starting point. The research challenge is to refine these principles, identify gaps and to gather further evidence about the potential of formative assessment and feedback to support self-regulation.

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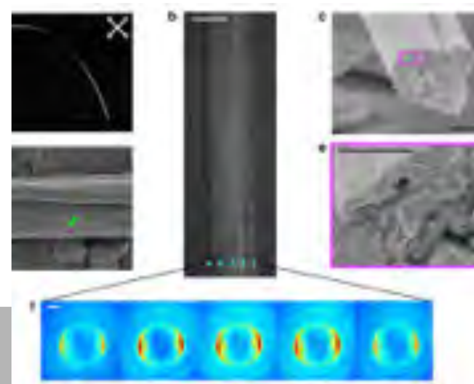

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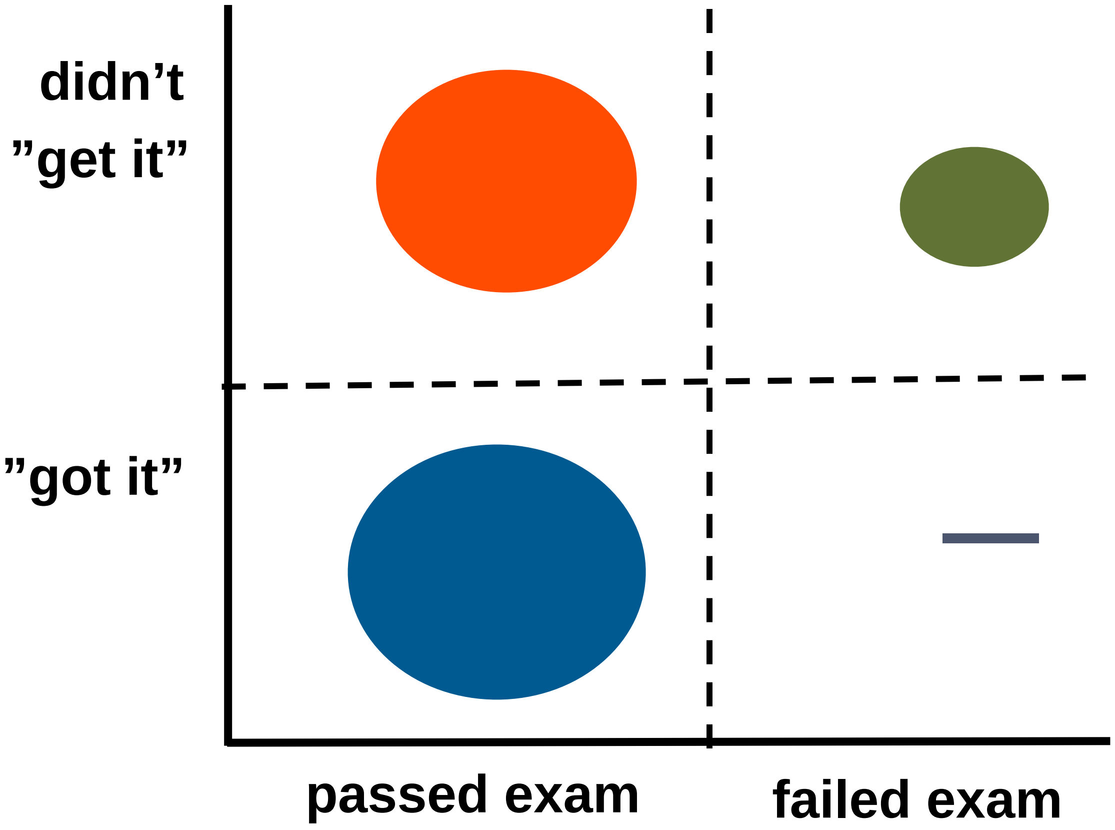

Conceptual understanding

- Not just reproduction of known solutions to known problems
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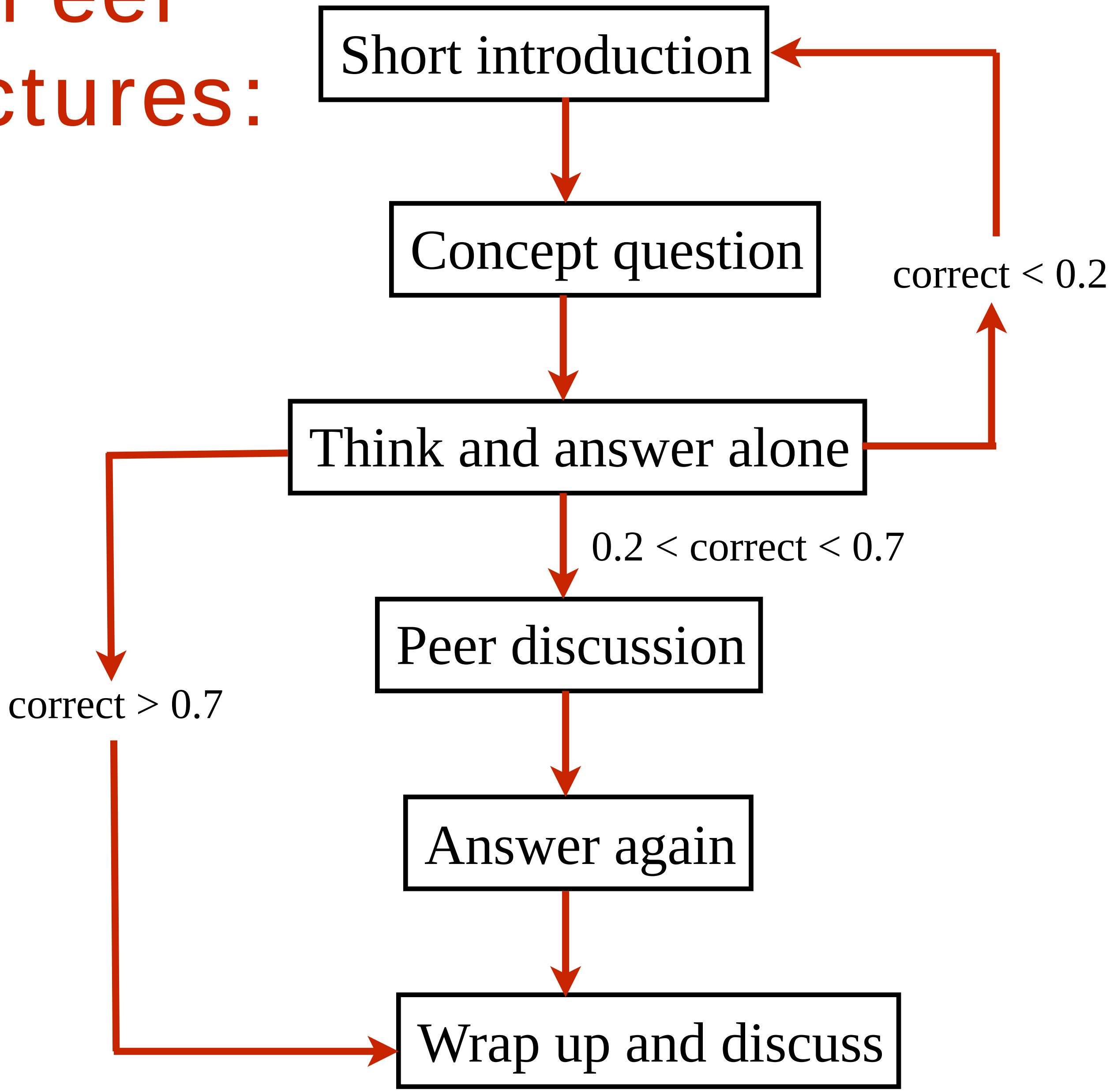
Flow chart for Peer Instruction Lectures:



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Fish ”breathing”

Fishes takes up oxygen in the form of:

1. Watermolecules, H_20
2. Ozon, O_3
3. Oxygenmolecules, O_2
4. Carbonate, CO_3

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Material flows in society

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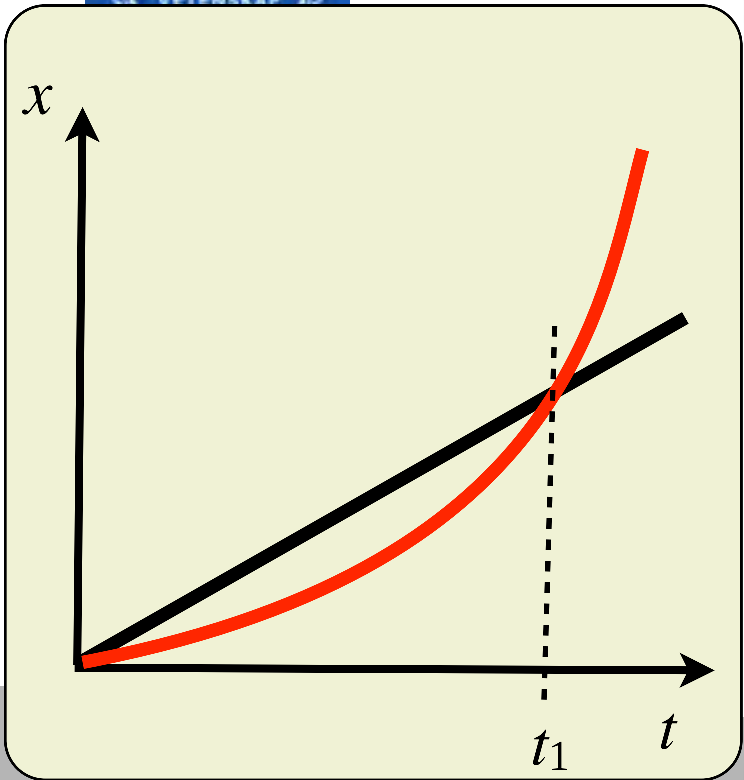
A car is filled with 30 kg of gasoline. The total weight of the exhausts leaving the car while using this gasoline is:

1. Less than 30 kg.
2. Around 30 kg.
3. More than 30 kg.
4. Can be both more and less than 30 kg depending on temperature and air pressure.

Concept: *Speed and acceleration*

first derivative, inclination: **second derivative, curvature:**

$$v = \dot{x} = \frac{\mathrm{d}x}{\mathrm{d}t}, \qquad a = \ddot{x} = \frac{\mathrm{d}^2 x}{\mathrm{d}t^2}$$



Two trains run on parallell tracks according to the graph. What is true?

1. Both trains have the same velocity at t_1.
2. Both trains increase their speed before t_1.
3. Both trains have the same velocity at some instance before t_1.
4. Both trains have the same acceleration at some instance.

Concept: *Speed and acceleration*

first derivative, inclination: **second derivative, curvature:**

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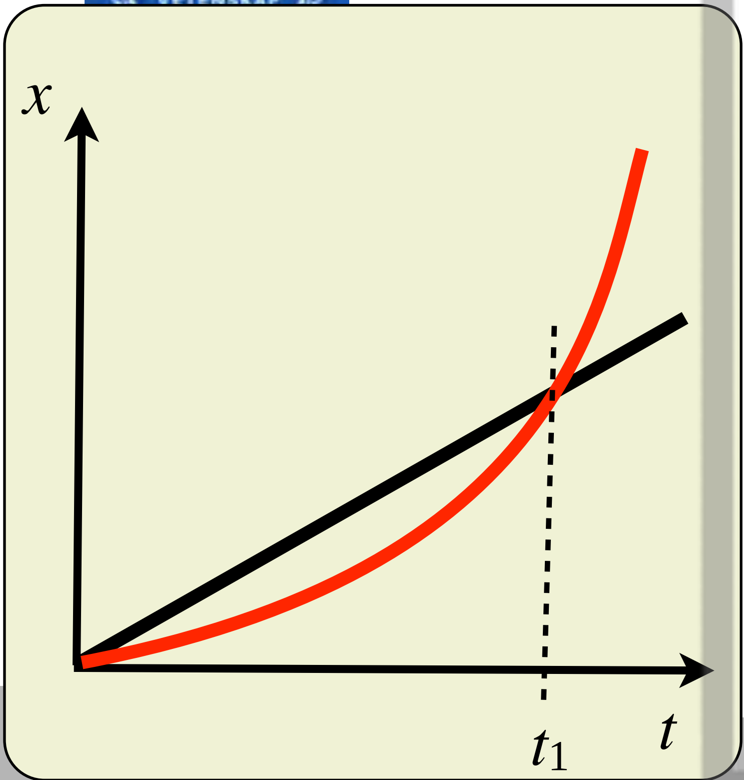

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3. Both trains have the same velocity at some instance before t_1.
4. Both trains have the same acceleration at some instance.

SG1102 2011:

	Before PD	After PD
1	24 %	14 %
2	5 %	4 %
3	**60 %**	**77 %**
4	11 %	5 %

Formulate a concept that you would like to write a concept question on!

The basic mechanics course

- 30 h lectures, 15 h recitations
- 100+ students
- Two written exams: theory (derivations)+problemsolving
- Difficult course according to students

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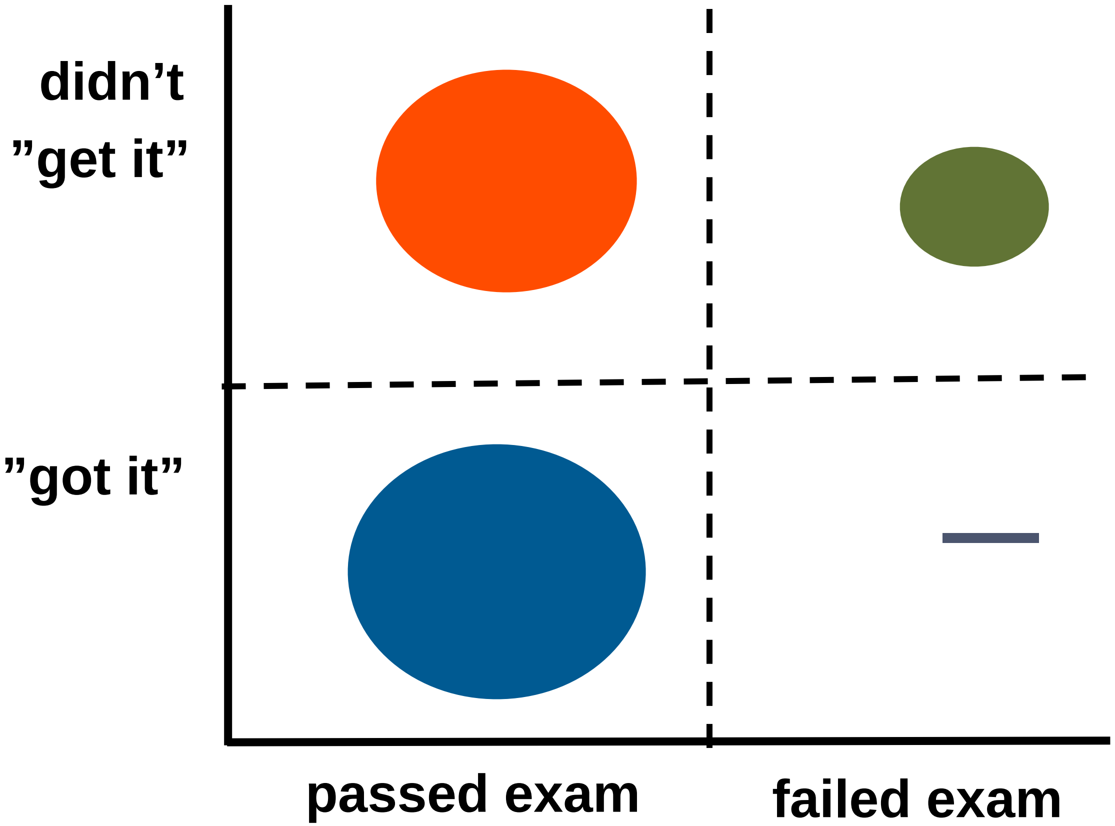
Issue with my teaching

KTH Teknikvetenskap



Conceptual understanding

- Not just reproduction of known solutions to known problems
- Being able to explain what they do and why
- Deeper working disciplinary knowledge

See for instance Mazur, E. (1997) *Peer Instruction*, and Kember & McNaught (2007) *Enhancing University Teaching.*

A student perspective

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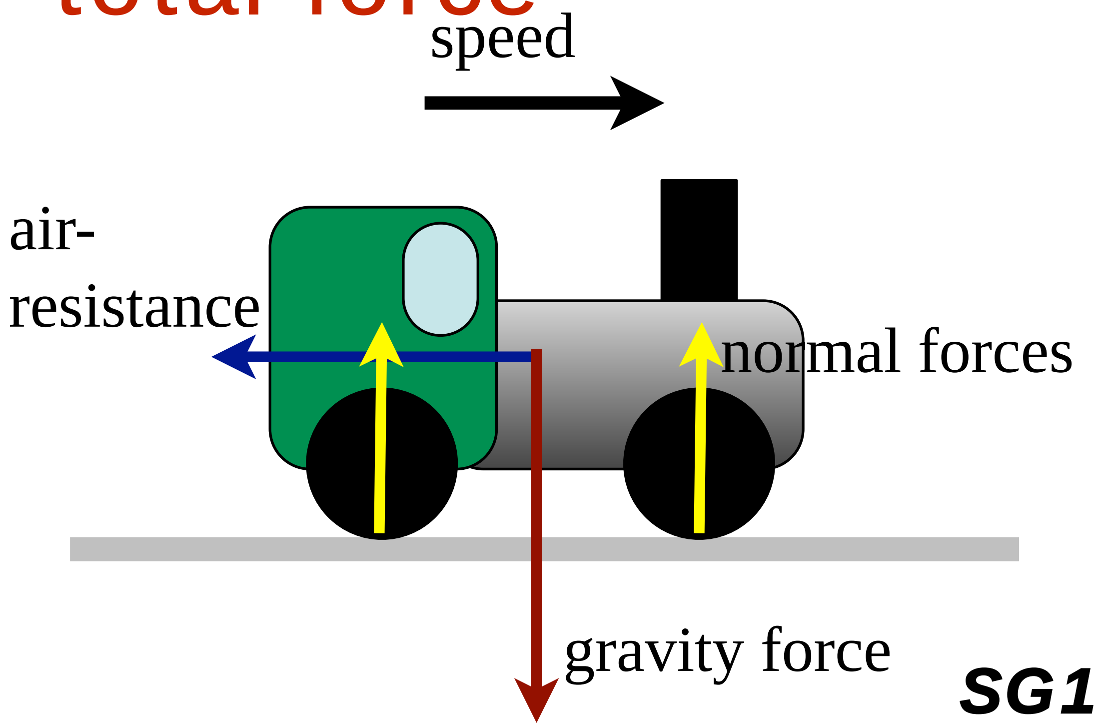
”When working on the previous exams, I notice that your exams are on a ”higher level” than the ones by other esaminers: your problems vary a lot. The issue is that I, as a student, cannot learn how to solve certain problems and demonstrate this at the exam. Can you please make the exam look more like the ones by the other teachers?”

Email from worried student day before the exam

Concept: friction force and total force



What is the direction of the friction force on the driving wheels?

1. forward
2. backward

SG1102 2011:

	Before PD	After PD
forward	**49 %**	**85 %**
backward	51 %	15 %

Concept: *Work U*

$$\mathrm{d}U = \mathbf{F} \cdot \mathrm{d}\mathbf{r}, \qquad U = \int_{\mathbf{r}_1}^{\mathbf{r}_2} \mathbf{F} \cdot \mathrm{d}\mathbf{r}$$

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Raise up:

	Before PD	After PD
>0	43 %	31 %
<0	**35 %**	**45 %**
=0	17 %	16 %
Not well defined	5 %	8 %

Sit down:

	Before PD	After PD
>0	**70 %**	**95 %**
<0	30 %	5 %
=0	0 %	0 %
Not well defined	0 %	0 %

The work U performed by gravity on your head as you rasied was:

1. >0
2. <0
3. =0
4. Not well defined

An elevator is moving upwards with constant speed, ignore friction

What is true about the force in the wire in which the elevator hangs?

1. The wire force is bigger than the weight of the elevator.

2. The wire force is equal to

3. The wire force is smaller

elevator.

4. The wire force is bigger t

elevator plus a force from th

5. Constant speed->forces

moves upwards because the

SG1102 2012:

	Before PD	After PD
1	35 %	2 %
2	**29 %**	**87 %**
3	1 %	0 %
4	8 %	1 %
5	27 %	10 %

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Result on the concept questions during a course in basic mechanics

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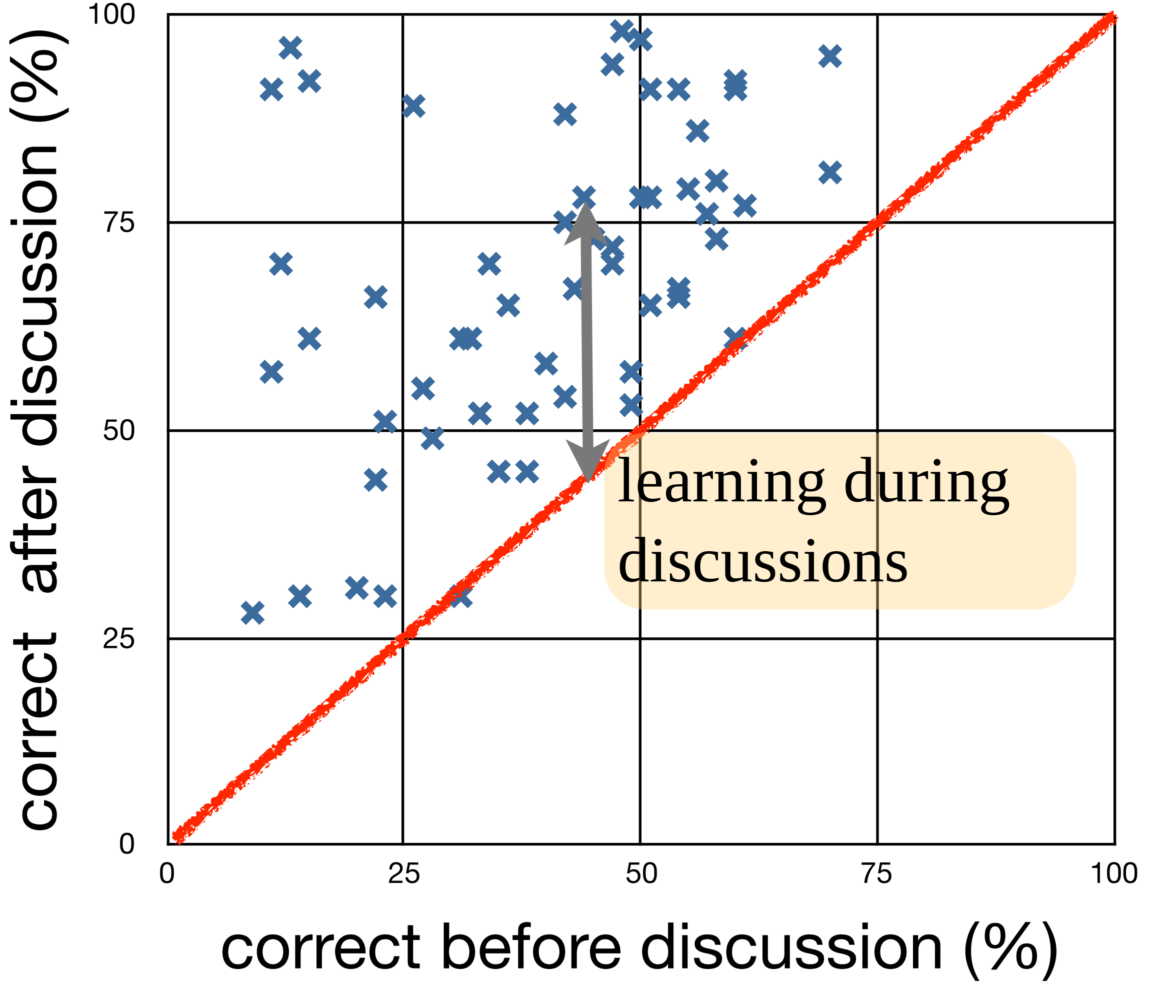

Problemsolving exam results, SG1102

	OPEN (Lundell)	**Control group (same exams)**
Spring 2010 *(No PI)*	P: 71% ≥C: 37%	P: 71% ≥C: 28%
VT 2011 *(PI in Open)*	**P: 86%** **≥C: 41%**	P: 59% ≥C: 20%
VT 2012 *(PI in Open)*	**P: 73%** **≥C: 46%**	P: 49% ≥C: 30%

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Theory exam results, SG1102

	OPEN (Lundell)	**Kontrollgrupp**
Spring 2010 (No PI)	P: 78% ≥C: 56%	P: 67% ≥C: 41%
Spring 2011 (PI in Open)	**P: 92%** **≥C: 65%**	P: 60% ≥C: 34%
Spring 2012 (PI in Open)	**P: 97%** **≥C: 82%**	P: 72% ≥C: 52%

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Choose one of the concepts at the table and write a multiple choice concept question!

Add the concept question from your table here:

http://tinyurl.com/EEE171018-1

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Prereading task, SG1102

Name:____

Civic number:___________________________ Lecture number:__________

Quantities introduced in this chapter:

Symbol	Name	Vector or scalar?

Describe what the direction and length of the vector quantities represent:

Formulas derived in this chapter. Give name (if existing), equation and whether the relation is general or the solution of an example:

This is something I still don't understand in this chapter:

Even more ways of using concept questions!

Choose a number in the range 1-5!

Do not choose the number of ”your” question.

http://tinyurl.com/EEE171018-1

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And even more!

http://tinyurl.com/EEE171018-1

More inspiration:

- *Peer Instruction* by **Eric Mazur**

- **www.peerinstruction.net**: Community for Peer Instruction users (2500 members!)

- http://www.cwsei.ubc.ca/ , initiative by **Carl Wieman** (Nobel laureate 2001), a lot of evidence-based material

- **www.flaguide.org:** Field-tested Learning Assessment guide: examples on lecture activities with documented effects

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Evaluation

http://tinyurl.com/EEE171018-eval

The Teaching Trick

– how to improve student learning without spending more time teaching

Kristina Edström
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Kristina Edström

Engineer & Educational developer

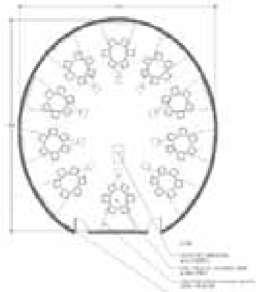
- M. Sc. in Engineering, Chalmers
- Associate Professor in *Engineering Education Development* at KTH Royal Institute of Technology, Stockholm, Sweden
- 700 participants in the 7.5 ECTS course *Teaching and Learning in Higher Education*, customized for KTH faculty, 2004-2012
- Director of Educational Development at Skolkovo Institute of Science and Technology, Moscow, 2012-2013

Strategic educational development, national and international

- CDIO Initiative for reform of engineering education since 2001
- SEFI Administrative Council, 2010-2013

Some publications

- Crawley, E.F., Malmqvist, J., Östlund, S., Brodeur, D.R., and Edström, K. (2014) Rethinking Engineering Education: The CDIO Approach, 2nd ed., Springer Verlag
- Edström, K., & Kolmos, A. (2014). PBL and CDIO: complementary models for engineering education development. European Journal of Engineering Education, 39(5), 539-555
- Edström, K. (2008) Doing course evaluation as if learning matters most, Higher Education Research & Development, 27:2, 95 – 106



Cost-neutral interventions

To persuade the grumpy professor to listen

To support those dedicated to teaching

Anyone can improve a course (at least some little bit) by working 100 hours more…

Yeah. We don't have those hours.

And "more of the same" is probably not the most effective strategy either…

We want to **improve (maximise) student learning**
with a given (or reduced) level of
teaching resources

$$\eta = \frac{\text{Output}}{\text{Input}}$$

Then we need pedagogical know-how!

Pedagogical competence

1. **setting clear objectives**
   (intended learning outcomes)
   - relevant for the study programs
   - defining the threshold level of quality
   - deeper working understanding
2. **uphold the threshold level of quality**
   - only pass the students who reach the goals
3. **create a course which generates appropriate learning activity**
   - so students actually reach the goals
   - good throughput - with good quality

Or in other words…

Formulating intended learning outcomes

What should the students be able to do as a result of the course?

Designing activities

Designing assessment

Constructive alignment [Biggs]

What work is appropriate for the students to do, to reach the learning outcomes?

What should the students do to demonstrate that they fulfil the learning outcomes?

Pedagogical competence

1. setting clear objectives
(intended learning outcomes)
- relevant for the study programs
- defining the threshold level of quality
- deeper working understanding

2. uphold the threshold level of quality
- only pass the students who reach the goals

3. create a course which generates appropriate learning activity
- so students actually reach the goals
- good throughput - with good quality

4. and doing this while using teacher time effectively
- generate appropriate study for the students
- spend your time where it has effect on learning
- create a sustainable workload for yourself
- and sustainability for your institution and country

The teaching trick

Do more of that which contributes to learning — ***Pretty easy***

But since we don't have 100 hours more:

Do less of that which does not contribute — ***Pretty hard***

Which one is easier and which one is harder?

Examples are illustrations of principles

A specific **example**

will **illustrate**

generic principles

to **inspire**

applications
- of many different kinds.

Pick one!

/* No comments */
Family dinner
Invest 0,20 €
Seven minutes
Cheap precision
Master test
Fireworks

maybe later:

Ultimate frisbee

/* No comments */

The teaching trick:

Do less of that which does not contribute

Spend less time on…
”finishing” student work!

Professor S told us:

”**I got 60 reports.** It is a boring task to give feedback and it **takes me two weeks.**

I gave individual comments and asked those who had failed to re-submit.

When the reports came back they were still bad. The students had only corrected the things I specifically commented on. They did not even read the rest!

Next year I did not give individual feedback on failed reports. Instead **I made a list with the most common errors**. Now the students had to **find their own** errors. When I got the reports back they were **generally very good**!”

Remember the purpose

- The purpose **is not**
  that *this particular* report should be good
- The purpose **is**
  that the **student should develop the skills** to write reports
  (so that he/she can write 1000 excellent reports later)

For the same reason:

Keep your hands on your back…

when you are assisting students in the computer lab
– do not ever touch their keyboard!

Every time you tie the shoes for your child, you hinder her own development.

Maria Montessori

Family dinner

The teaching trick:

Do less of that which does not contribute

Spend less time on…
marking coursework!

What Professor K does…

The weekly assignment cycle drives the course

The weekly cycle

7 Monday

Feedback session

i. Students papers are exchanged randomly, and they write feedback with a red pen.
ii. Students receive & read their feedback immediately.
iii. Advanced and lively discussions!

Afterwards, teacher collects reports (or copies) for grading.

- Feedback session
- Introduce new content
- Homework

Workshop

- Students work on homework
- Support and discussions if needed

1. Read theory and implement the method
(straight-forward implementation)
2. Test and verify implementation
(normal use and extreme cases)
3. Investigate creatively
(test variants, how would it work if…, play around, think for yourself)
4. Write short report (2 or 3 pages)
(describe methodology, limitations etc and own initiatives)

Here comes the trick: Easy marking ☺

Grading scale

- Fail = 0p (Seldom happens)
- Pass = 1p (Typical grade)
- Brilliant = 2p (Requires lots of own initiatives)

\+ With accepted participation in the feed-back loop +1p

Easy to see the difference between 0, 1 or 2 points, in fact it only takes about 1-3 minutes per paper…

Points	Grade
25-28	A
21-24	B
17-20	C
14-16	D
11-13	E
0-10	Fx

At the end of the course, points are converted to final grade (no exam)

\+ In some courses there is also an oral exam

The principle is to separate the processes

– then both can be made cost-effective

Feedback for learning

- made into a group learning activity
- intense involvement
- learn to discuss the subject
- immediate feedback
- expose variation
- social motivation

Assessment for grading

- by the teacher
- minimalistic
- sufficiently fair

Good for learning!

Continuous studies

- Distributes student effort during the course.

The formative feedback session *as a whole* (giving feedback, getting feedback and discussions) **generates learning**:

- Repetition – Variation – Fast feedback.
- Deep & interesting discussions (instead of discussions on definitions).
- Social motivation – expose your understanding to others and see theirs.

Satisfaction:

- Students feel that the teacher really cares about their work.
- Clear, fair and transparent grading system.
- Students feel their progression.

Good for the teacher!

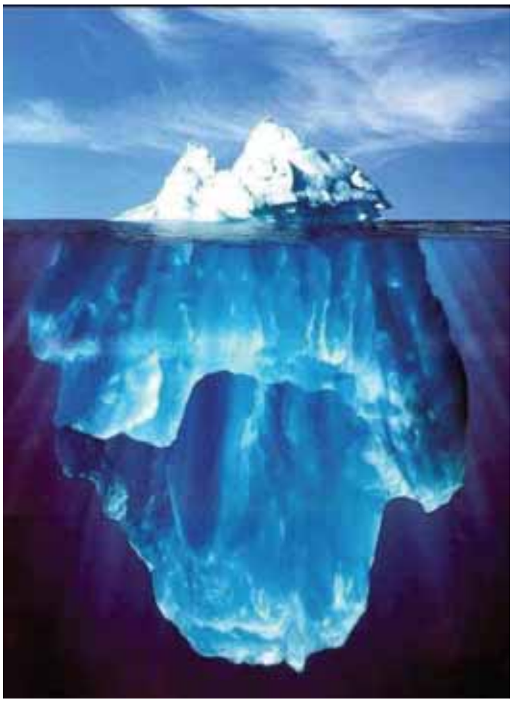
- ≈1-3 minutes per paper.
- Final grading is no extra work ☺

Invest 0,20 €

The teaching trick:

Do less of that which does not contribute

**Spend less time on…
learning activities that don't
generate appropriate study!**



The Iceberg Principle

Group work with random presenter

Tell them on day one:
All students in the group should be ready to present the whole project and take questions on all parts

Last minute:
Choose the presenter randomly

Students choose

- It is possible to hide behind strong students
- There is little incentive to learn about each others work
- Only the best presenter will practice presenting
- Towards the end it is mainly the presenter who is working

Random choice

- Everyone knows you cannot hide
- Everyone must learn about all parts
  - what questions can we expect to get on X?
  - why did we choose to Y?
- Everyone will practice presenting

What is the cost?

About 0,20 €

The real cost is explaining the setup for the students

Some students will say:

- *It is unfair!*

You explain:

- *It is. But, you see, the previous setup was unfair too. But now the learning will be much better for all!*

Seven minutes

The teaching trick:

Do less of that which does not contribute

Spend less time on…
designing and correcting exams!

Oral exams are really good for learning

- Better **test of understanding** & can be individually tailored
- **Affect student preparation** – they know they have to show "real" understanding, in real time (create the right expectation)

Some teachers are nervous about…

...inventing the necessary questions

- The trick: Reverse the burden of proof ("*the first 7 minutes are yours, to show me that you have reached the learning outcomes*")
- Follow-up questions will pop up!

…grading

- Use a simple scale: Fail / 10p / 20p

...having to fail students

- Photograph the written start for documentation
- Ask kindly how they think it went

…the time it takes

- But it is cheaper for a course of up to *N* students
- What is *N* for your course? Do the math!

Katrin taking an oral exam

Written- vs oral exam, teacher time

Written:

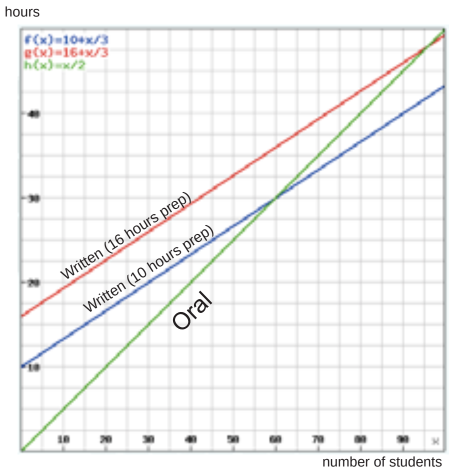
Design and construction of exam and solution-sheet takes ≈ **10-16** hours.

Correcting one exam takes ≈ **20** minutes

Oral:

The exam takes ≈ **30** minutes.

Moreover: Consider the gain at re-exam!



*"We have 400 students in Introductory Physics…
but we also have more than 10 professors
who know the subject!"*

Cheap precision

Learning objectives – Intentions vs. Reality

What really counts is **not** what the learning objectives state
it is the **actually assessed learning outcomes required for passing**.

Admit that we often have limited control over the threshold for passing:

- Can we really describe in qualitative terms what a pass means?
  If we e.g. require 40% correct answers on the exam,
  - what does that really mean?

- And what about all the individual professional *skills*
  that are often only practiced and assessed in groups?

This is a **fundamental uncertainty** regarding the contribution
of each course in relation to the program learning objectives.

An exam design to improve the threshold control

1) Formulate the learning objectives in two levels:

For pass
you should be able to...
⋮

For the higher grades
you should also be able to...
⋮

2) Split the exam into two parts:

- **Part A**
  For passing a high score is demanded, say 75%,
  or why not 99% or higher!?
- **Part B**
  The score here decides the grade.

- **This gives us firmer control of the pass threshold** (the most crucial quality threshold)
- **Students will learn part A very carefully -** make sure this covers the "core" of the course and the prerequisites for later courses
- **Bonus: We can eliminate some of the least meaningful work of correcting exams** (part B is only corrected for students who pass A)

Master test

The teaching trick:

Do less of that which does not contribute

Spend less time (energy) on…
listening to students complaints!

Before:

There were two individual assignments in the course:

- **Homework 1 & 2**

The tasks were complex and theoretical…

Students complained bitterly and endlessly:

- *The assignments come too EARLY before we know how to do this!*
- *They are far too DIFFICULT and take TOO MUCH TIME!*

What Professor V did:

The assignments were renamed:

- **MASTER TEST 1 & 2 (MÄSTARPROV)**

What happened?

- Complaints just stopped
- Students take the assignments very seriously – and are very proud!

…other interesting words…

Accident investigation
Weekly challenge
Show
Master test
Demonstration
Gymkhana
Show & Tell
Fair
Keynote
TED talk
Potluck
Conference
Deadline
Inspection
Q&A session

Evaluation
Summit
Negotiation
All hands on deck
Campaign
Consultancy
Pitch
Elevator pitch
Pecha kucha
Speed dating
Match
Audition
Ceremony
Installation
Inauguration

Time out
Grand challenge
Dress rehearsal
Opening
Court hearing
Stop-press
Workout
Personal training
Vernissage
Hearing
Review
Test pilot
Advisory group
Working party

Certificate
Jam session
Dissection
Hackathon
Talk show
Level up
Expert panel
Investigation
Workshop
Emergency room
Launch
Countdown
Pit stop
Meeting

Fireworks

The teaching trick:

Do less of that which does not contribute (especially if it is expensive)

Spend less time on… writing feedback

Tax payer's money down the drain!

Make the distinction between:
- feedback for learning
- justification of grade
  (does not generate learning, minimize cost)

~ 40 students write an open-ended assignment of 4 pages
(e.g. essay, design, reflection…)

- The assignment is personal and important (a credo).
- It would take several days to write good feedback!
- Instead a final seminar
  - Intensive learning activity
  - Plenty of peer feedback and some from the teacher
  - Minimal summative assessment, sufficiently fair (pass/fail grade)

- The teacher skims essays and makes quick decision:
  - **Accepted** to join the seminar
  - **Pending acceptance**, allowed to join but must submit improved version after the seminar (and they must tell the group and ask for guidance)
  - **Reject**, cannot join and must redo assignment the next time the course is given
- Divides the students in groups of 4
  (Usually one excellent essay, two medium good, and one needing improvement)
- Sends mail with instructions
  - **Download** your colleagues' work (from the digital platform).
  - **Write ½ page constructive comments** to each colleague, *strong aspects and how the work can be improved*.
  - **Bring** prints of comments to the seminar
    (4 for the group + 1 to the teacher).
- This takes maximum 2 hours…

Teacher prepares feedback before the seminar

- Merges all essays into one big pdf.
- Searches for **a strong aspect** in each text, making sure to cover the things that are important in the course.
- Marks the passage with a ”star” in the margin with some keywords.
- This takes just as long time as a hockey game ☺

[Recommending the GoodReader app for annotations]

At the seminar – group feedback

- Discuss each essay with the aim to improve it (4*30 minutes).
- Meanwhile, the teacher reads the written comments (to see that they were taken seriously + as input)
- Their feedback is quite useful
  - Students are really good at pointing out deficiencies
  - Getting three different comments on your essay is great

End with fireworks

1 hour in plenary:

- Display the pdf and discuss each ”Gold Star” full of enthusiasm and passion (fireworks). Bring it on!
- End by recommending 3 – 4 essays to read before writing version 2.0 (for most students it is voluntary).
- Publish the pdf in the digital platform as an invitation to browse.

Ultimate frisbee

Dear Professor,

I coach the women's **ultimate frisbee teams** and based on your workshop I changed our program for the **practice weekend**.

Normally, since a game only involves 14 players, we would rotate and the others would do some drill on the side.

Now, instead, I had a non-playing team standing on the sidelines and assigned each of them a player. Then I stopped the game periodically and had the sideline players give individual feedback to their assigned player.

It went over remarkably well. A number of the ladies had very positive feedback, and said they had numerous strategy talks that they found incredibly helpful. It was also great for me, since I can't possibly watch every player all the time. It was incredibly time efficient!

So in conclusion, thanks again for the workshop. I thoroughly enjoyed it, and I thought you might like hearing about an application in a completely different "field"!

Best regards,
Professor D

The trick question

Do more of that which contributes to learning
(especially when it is cheap)

Easy part

Do less of that which does not contribute
(especially when it is expensive)

Hard part

Doing additional things *on top of the old* is not sustainable…

So why do we often keep doing things that are less effective for learning?

Discuss with your neighbours

- lack of student motivation
- we are coming from traditional ways of teaching – teachers want to teach as much content as possible, they think their subject is the most important
- teachers initiative is restricted by high bureaucracy
- our students are not used to working individually or in groups from high school, and we have 40-60 students in seminars
- resistance to change makes us continue the way, in our comfort zone
- too much papers to fill in, too much bureaucracy and planning
- we are thinking theoretically about the course, not in a practical sense
- the motivation of the teachers, both the moral and financial motivation is lacking
- we don't have time to do the hard part, also financial problems, and we have so many other activities that take time and energy
- age and attitude (of teachers)

What reasons can there be…?

- Convenience – if I use traditional methods, there is no need to think, to make decisions, to explain, to defend, to persuade, to take responsibility…
- It is true – we actually never thought of this because we truly believed that it would always take more time
- Student expectations (or what we think they want)
- Colleagues expectations (or what we think they think)
- We teach in ways that make us feel good ourselves (lecture, have answers to everything, finish student work so it looks good…), without thinking so much about learning
- We have not reflected on our routines and traditions
- Lack of knowledge and fantasy in course design
- We think education is more about sorting people than adding value
- We actually think that everything is the students' fault
- Minimising risk:
  "when the old model doesn't work, it is the student's fault,
  but if I try something new and it doesn't work, then it is all my fault"

Remember that we are here to improve education

The tricks are not just "oil in the machinery"

More importantly they imply

QUALITY TIME WITH YOUR STUDENTS

- more meaningful and fun, because it is value adding!

How to talk with students about this

NEVER SAY:
this is ”alternative” – I learnt a trick – I'm saving my time 

Show that this truly belongs in the education

Several tricks address competences relevant for most educational programs. Make this explicit in the learning objectives!

After the course you should be able to (for instance)

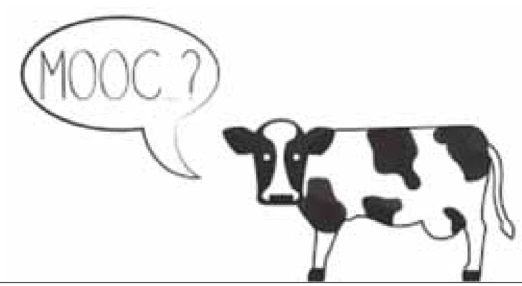
- evaluate your own work and the work by others…
- critically analyse and give feedback on…
- critically assess alternative solutions…
- orally present and discuss your conclusions and the underpinning knowledge…
- argue and contribute in discussions about…

Student: *Why do I need to read their report?*
Teacher: *Look at the course learning outcomes. This is how you practice to…*critically review and give feedback on technical solutions! You will need that in working life.

It is also about a more stimulating role for teachers

Value-adding processes are often more stimulating
The least value-adding processes are often boring routine tasks

Also note that the most value-adding processes are the last to be replaced…



My hidden agenda

Enabling educational development by addressing the implementation

Furthering a learning perspective by gift-wrapping it

And we only live once…

Now let’s discuss…

+

- What do students need more of?
- What do you want to do more of?

-

- What do you want to do less of?

Welcome to LH219V Workshop D
Academic Writing

Please discuss in a small group your own experiences of “academic writing”.

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- Course convenor for 6 courses in English for specific purposes:
  - Pre-sessional course in Study Skills & English for Academic Purposes
  - B1 English: Essential Grammar and Vocabulary
  - English for Writing & Presenting a Degree Project (LS2439)
  - Rhetoric: Speaking & Writing with Impact (LS1465)
  - English for Employment (LS1419)
  - Technical Communication (LS2429)
- Tutor at the Centre for Academic Writing **kth.se/caw**
- Tutor for WSA course for doctoral students **DS1302**
- Global Engineers' Language Skills (GELS) project

Engineers need to be able to communicate efficiently

- Employers expect this of KTH graduates
- Writing is a skill that requires
  - Input
  - Practice
  - Feedback

A look at MIT

- Four courses designated as communication-intensive for the B.Sc

Guidance in writing is especially important for our students

- Input
- Practice
- Feedback

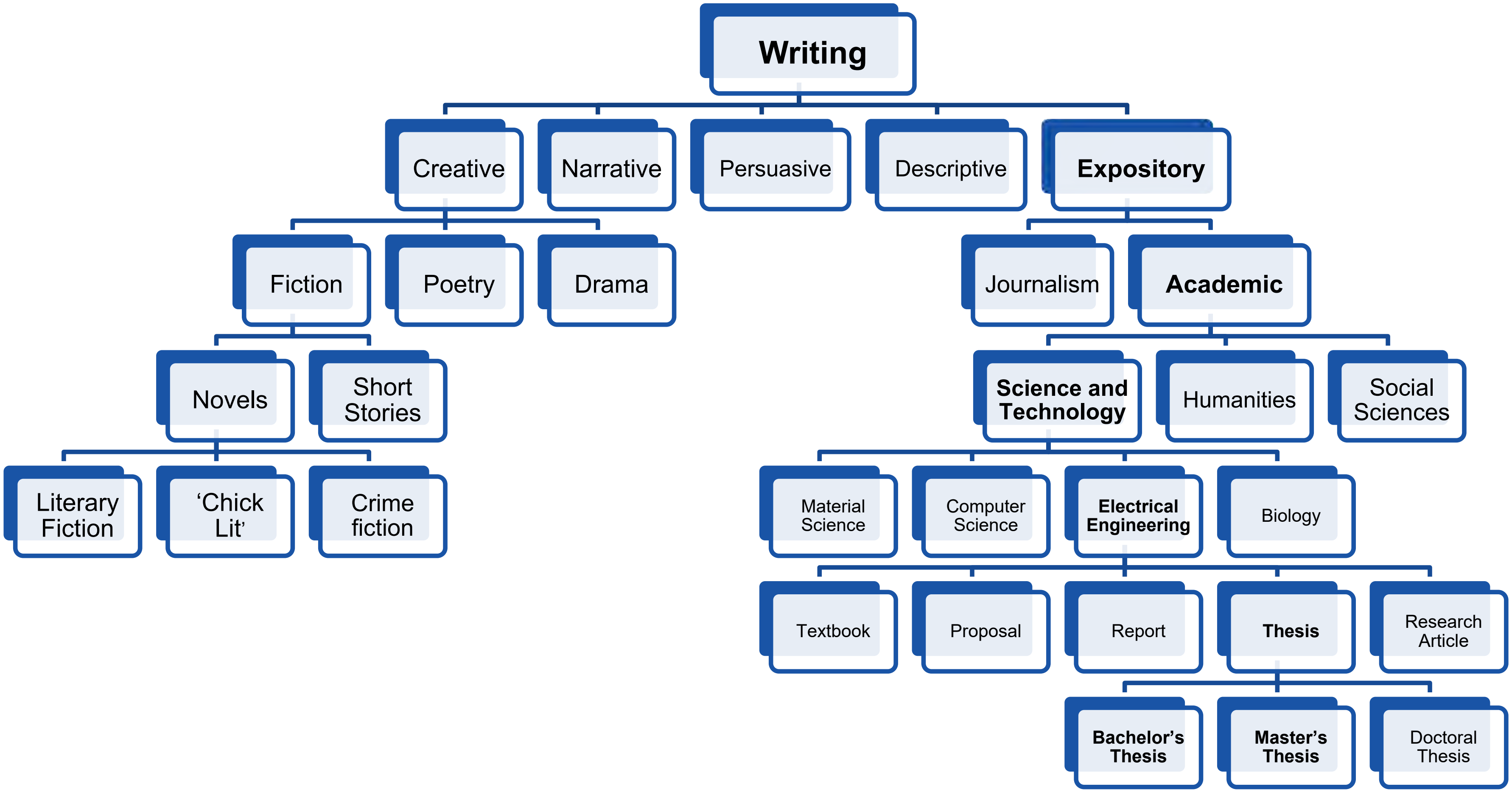
Our plan today

Input	Practice	Feedback	Finish
• Writing in Science and Technology • Writing a thesis	• Some good practice at KTH • Starting early • Break at around 10.30	• Reader-friendly vs. linguistically accurate • Seven principles of good feedback	•Workshop evaluation

Input

Briefly discuss this question

1. What mechanisms are in place within your program to support student mastery of academic writing?


Writing
Creative
Narrative
Persuasive
Descriptive
Expository
Fiction
Poetry
Drama
Journalism
Academic
Novels
Short Stories
Science and Technology
Humanities
Social Sciences
Literary Fiction
'Chick Lit'
Crime fiction
Material Science
Computer Science
Electrical Engineering
Biology
Textbook
Proposal
Report
Thesis
Research Article
Bachelor's Thesis
Master's Thesis
Doctoral Thesis

Audience and Purpose

- Should be clear to the writer from the beginning
- Can guide writing all through life
- Audience and Purpose determine Organization
- Can have primary and secondary of each
- What are the audience(s) and purpose(s) of a degree project?

Four Cs of good Composition

Clear	Concise	Coherent	Correct
• Reader-friendly • Simply expressed • Logically-structured • Precise	• Economical • Direct	• Organized • ‘Glued’ together • Flows smoothly	• Grammar • Vocabulary • Punctuation

These qualities are seldom achieved in anyone’s first drafts

These concepts are emphasized in the degree project criteria:

- Clarity
- Coherence
- Organization
- Integration
- Independence
- Argumentation
- Planning
- Judgement
- Synthesis
- Analysis

Two words that do not appear are….

- Accuracy
- Correctness

You are not responsible for the quality of their English or Swedish

Activity 1.
Evolution of a text

Version 1

Using the wildtype protein, whereby the binding of Biotin molecules can not be regulated and multiple Biotin binding is possible, is disadvantageous. Multiple binding or binding close to the active binding site of Z-protein of Biotin lowers the affinity and are therefor not wanted. One drawback of the cysteine variant was that presence of multiple cysteine structure's might result of di-sulphide bonds, making it impossible for Biotin to bind to the protein and decrease the amount of protein open for the signal cascade.

Activity 1.
Evolution of a text

Cannot be speed-read
Final sentence too long
Unparallell structure
Unchecked language & grammar

Version 1

Using the wildtype protein, whereby the binding of Biotin molecules can not be regulated and multiple Biotin binding is possible, is disadvantageous. Multiple binding or binding close to the active binding site of Z-protein of Biotin lowers the affinity and are therefor not wanted. *One drawback of the cysteine variant was that presence of multiple cysteine* structure's *might result of di-sulphide bonds,* making *it impossible for Biotin to bind to the protein and* decrease *the amount of protein open for the signal cascade.*

Activity 1.
Evolution of a text

Version 2

Neither the wildtype protein nor the cysteine variant is ideal. The disadvantage with using the wildtype protein is that the binding of Biotin molecules cannot be regulated and therefore allows for multiple Biotin binding. Such binding lowers the affinity and is therefore not wanted. A similar drawback with the cysteine variant is that presence of multiple cysteine structures might result of di-sulphide bonds. This makes it impossible for Biotin to bind to the protein, thereby decreasing the amount of protein open for the signal cascade.

Activity 1.
Evolution of a text

Topic sentence enables speed-reading

Short, coherent sentences

Version 2

Neither the wildtype protein nor the cysteine variant is ideal. *The disadvantage* with using the wildtype protein is that the binding of Biotin molecules cannot be regulated and therefore allows for multiple Biotin binding. *Such binding* lowers the affinity and is therefore not wanted. *A similar drawback* with the cysteine variant is that presence of multiple cysteine structures might result of di-sulphide bonds. *This* makes it impossible for Biotin to bind to the protein, thereby decreasing the amount of protein open for the signal cascade.

Activity 1.
Evolution of a text

Version 3

Neither the wildtype protein nor the cysteine variant is ideal. The disadvantage ~~with~~ of using the wildtype protein is that the binding of Biotin molecules cannot be regulated and therefore allows for multiple Biotin binding. Such binding lowers the affinity and is therefore ~~not wanted~~ undesirable. A similar drawback with the cysteine variant is that the presence of multiple cysteine structures might result ~~of~~ in di-sulphide bonds. This presence ~~makes it impossible for~~ prevents Biotin from binding to the protein, thereby decreasing the amount of protein open for the signal cascade.

How do we get the students to produce a text that meets our requirements?

- Build skills starting early in the program
- Reading, reading, reading
- Models, good and bad
- Noticing
  - What is the difference between and abstract and an introduction?
  - What goes in methods and what goes in results?
  - How can I impose a structure on my introduction/discussion?
- Critically examining other’s work (peer review)

Practice

Plenty of good practice at KTH: an example from CSC

Meeting	Submission	Peer Review
1. Start-up	Task description	Task assessment linked to important points
2. Project planning	Thesis specification	Specification assessment linked to degree goals
3. Literature study presentation	Literature/theory summary	Literature review (references, clarity, structure, strengths)
4. Half-time meeting	Report skeleton	Report (structure, current content)
5. Preliminary report meeting	Preliminary report	Report, same protocol as for the opposition.

Examples of writing courses integrated in programs

- EES
  - Groups of six (!) first- or second-year students who take a seminar in Global Challenges
- ABE
  - Essay-writing course in first term, *Samhällsbyggnadsprocessen*
- CSC
  - Communication course for first-years
- ICT
  - Distributed Computing includes LS2429 with Jamie

Students must be writing throughout their time at KTH

Oppose these arguments!

- *They should have learned how to write before they arrived*
- *They should have learned how to use sources before they got here*
- *The work has been done, now all that remains is to ‘write it up’*
- *We teach ‘doing’ engineering, not writing about it*

Tips for making this possible

- More individual writing
- Include a KTH Language course in your program
- Designate communication-intensive courses spaced throughout the program
- Encourage students to use the CAW
- Encourage students to attend the ARC´s lunchtime seminars
- Have clear examination goals for the communication components of these courses
- Provide input on targeted skills for the assignment
- Consider making term-length assignments

Feedback

For linguistic accuracy

- Require use of spellcheckers
- Require use of grammar checkers
  - Note that there is no grammar checker for LaTeX
  - LaTeX is a typesetting program, not a word processor
- Refrain from commenting on problems a computer could find
- Require peer review
- Refer students to the Center for Academic Writing
- Refer students to language courses

Activity 2.
What you might give feedback on…

1. Do you think you give too little or too much feedback?
2. Look at the handout.
3. Rank the 5 criteria in terms of importance for helping students to submit a better thesis
4. Be ready to justify your ranking

Reviewing a thesis

First draft?

- Question/purpose
- Answer to question
- Overall organization of paper

Middle draft?

- Style
- Composition
- Flow

Final draft?

- All of the above
- Grammar
- Spelling

Activity 3.
Seven principles for giving feedback

1. Clarify what good performance is
2. Facilitate self-assessment
3. Deliver high-quality feedback information
4. Encourage teacher and peer dialogue
5. Encourage positive motivation and self-esteem
6. Provide opportunities to close the gap
7. Use feedback to improve teaching

How can you use two of these principles to inform how you can give feedback on academic writing?

Come up with 6 specific ideas (3x2).

David J. Nicol & Debra Macfarlane-Dick (2006) Formative assessment and self-regulated learning: a model and seven principles of good feedback practice, *Studies in Higher Education*, 31:2, 199-218, DOI:10.1080/03075070600572090

1. Clarify what good performance is

- Provide examples of successful work (thesis, chapter, paragraph)
- Encourage the students to read and evaluate the communication strategies (i.e. language, structure, rhetoric) in work by previous students
- Provide opportunities to discuss and reflect on grading criteria
- Discuss communication explicitly before the students begin writing their theses
- Peer review focused on communication

2. Facilitate self-assessment

- Integrating self-assessment, peer review and teacher feedback with a focus on communication (via BILDA)
- Encourage students to think and talk about the in/effective communication strategies of their work before they start writing a thesis

3. Deliver high-quality feedback information

- Three well thought-out comments?
- Be constructive rather than judgemental
- Be specific
- Focus on the students’ communication of ideas rather than their words
- Praise good communication
- Give praise and criticism in terms of how you experienced the effects of the language and structure used instead of making judgemental comments
- Don’t correct what the students should be able to correct themselves (CAW, peer review, grammar- and spellcheckers)

4. Encourage teacher and peer dialogue

- Before students write their thesis, they should be in the habit of giving and taking comments on writing
- Encourage the students to discuss how they can satisfy the communication requirements of the thesis
- Ask students how they are going to respond to your feedback on communication

5. Encourage positive motivation and self-esteem

- Create an opportunity for a low-stakes communication assessment before the students embark on their thesis
- Comment on students' quality of communication only after they have responded to feedback

6. Provide opportunities to close the gap

- Give feedback on drafts, not the final versions
- As many submissions as possible – with a specific communication target each time
- Invite students to set their own “communication action points” for the next submission

7. Use feedback to improve teaching

- Have students submit a communication-based question when they submit a draft, e.g. Should I write about what other researchers have done in the past or present tense?
- Have students highlight, before the submission of a draft, an area of communication they would like you to concentrate on

In a nutsell…

- Effective writing takes a great deal of effort: input, practice and feedback
- Students need to be reminded about AUDIENCE and PURPOSE
- Supervisors need to reminded that CORRECT is not the only C of good composition: CLEAR, CONCISE, COHERENT
- Effective language support/correction requires systematic priorities at the different stages of writing
- KTH Language & Communication is here to help!

Support from KTH Language and Communication

- Academic Resource Centre / Centre for Academic Writing
  - Lunch seminars
  - Individual tutoring
- Lectures and peer-review series for KEX-project
- English courses
  - Writing & Presenting a Degree Project
  - Rhetoric: Speaking & Writing for Impact
  - Technical Communication in English
  - Online course in English for Academic Purposes
- Swedish for Higher Education and Employment
- *Retorik* in Swedish

Other favorite resources

Swales and Feak, *Academic Writing for Graduate Students*

Hoffman, *Scientific Writing and Communication*

The **Online Writing Lab** at Purdue University

Murphy, *English Grammar in Use*

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The CDIO Standards 2.0

Standard 1 — The Context*

Adoption of the principle that product, process, and system lifecycle development and deployment -- Conceiving, Designing, Implementing and Operating -- are the context for engineering education

Description

A CDIO program is based on the principle that product, process, and system lifecycle development and deployment are the appropriate context for engineering education. Conceiving--Designing--Implementing--Operating is a model of the entire product, process, and system lifecycle. The Conceive stage includes defining customer needs; considering technology, enterprise strategy, and regulations; and, developing conceptual, technical, and business plans. The Design stage focuses on creating the design, that is, the plans, drawings, and algorithms that describe what will be implemented. The Implement stage refers to the transformation of the design into the product, process, or system, including manufacturing, coding, testing and validation. The final stage, Operate, uses the implemented product or process to deliver the intended value, including maintaining, evolving and retiring the system.

The product, process, and system lifecycle is considered the context for engineering education in that it is part of the cultural framework, or environment, in which technical knowledge and other skills are taught, practiced and learned. The principle is adopted by a program when there is explicit agreement of faculty to transition to a CDIO program, and support from program leaders to sustain reform initiatives.

Rationale

Beginning engineers should be able to Conceive--Design--Implement--Operate complex value-added engineering products, processes, and systems in modern team-based environments. They should be able to participate in engineering processes, contribute to the development of engineering products, and do so while working to professional standards in any organization. This is the essence of the engineering profession.

Rubric Standard 1

Scale	Criteria
5	Evaluation groups recognize that CDIO is the context of the engineering program and use this principle as a guide for continuous improvement.
4	There is documented evidence that the CDIO principle is the context of the engineering program and is fully implemented.
3	CDIO is adopted as the context for the engineering program and is implemented in one or more years of the program.
2	There is an explicit plan to transition to a CDIO context for the engineering program.
1	The need to adopt the principle that CDIO is the context of engineering education is recognized and a process to address it has been initiated.
0	There is no plan to adopt the principle that CDIO is the context of engineering education for the program.

Standard 2 — Learning Outcomes*

Specific, detailed learning outcomes for personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge, consistent with program goals and validated by program stakeholders

Description

The knowledge, skills, and attitudes intended as a result of engineering education, that is, the learning outcomes, are codified in the CDIO Syllabus. These learning outcomes detail what students should know and be able to do at the conclusion of their engineering programs. In addition to learning outcomes for technical disciplinary knowledge (Section 1), the CDIO Syllabus specifies learning outcomes as personal and interpersonal skills, and product, process, and system building. Personal learning outcomes (Section 2) focus on individual students' cognitive and affective development, for example, engineering reasoning and problem solving, experimentation and knowledge discovery, system thinking, creative thinking, critical thinking, and professional ethics. Interpersonal learning outcomes (Section 3) focus on individual and group interactions, such as, teamwork, leadership, communication, and communication in foreign languages. Product, process, and system building skills (Section 4) focus on conceiving, designing, implementing, and operating systems in enterprise, business, and societal contexts.

Learning outcomes are reviewed and validated by key stakeholders, that is, groups who share an interest in the graduates of engineering programs, for consistency with program goals and relevance to engineering practice. Programs are encouraged to customize the CDIO Syllabus to their respective programs. In addition, stakeholders help to determine the expected level of proficiency, or standard of achievement, for each learning outcome.

Rationale

Setting specific learning outcomes helps to ensure that students acquire the appropriate foundation for their future. Professional engineering organizations and industry representatives identified key attributes of beginning engineers both in technical and professional areas. Moreover, many evaluation and accreditation bodies expect engineering programs to identify program outcomes in terms of their graduates' knowledge, skills, and attitudes.

Rubric Standard 2

Scale	Criteria
5	Evaluation groups regularly review and revise program learning outcomes, based on changes in stakeholder needs.
4	Program learning outcomes are aligned with institutional vision and mission, and levels of proficiency are set for each outcome.
3	Program learning outcomes are validated with key program stakeholders, including faculty, students, alumni, and industry representatives.
2	A plan to incorporate explicit statements of program learning outcomes is established.
1	The need to create or modify program learning outcomes is recognized and such a process has been initiated.
0	There are no explicit program learning outcomes that cover knowledge, personal and interpersonal skills, and product, process and system building skills.

Standard 3 — Integrated Curriculum*

A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, and system building skills

Description

An integrated curriculum includes learning experiences that lead to the acquisition of personal and interpersonal skills, and product, process, and system building skills (Standard 2), interwoven with the learning of disciplinary knowledge and its application in professional engineering. Disciplinary courses are mutually supporting when they make explicit connections among related and supporting content and learning outcomes. An explicit plan identifies ways in which the integration of skills and multidisciplinary connections are to be made, for example, by mapping the specified learning outcomes to courses and co-curricular activities that make up the curriculum.

Rationale

The teaching of personal, interpersonal, and professional skills, and product, process, and system building skills should not be considered an addition to an already full curriculum, but an integral part of it. To reach the intended learning outcomes in disciplinary knowledge and skills, the curriculum and learning experiences have to make dual use of available time. Faculty play an active role in designing the integrated curriculum by suggesting appropriate disciplinary linkages, as well as opportunities to address specific skills in their respective teaching areas.

Rubric Standard 3

Scale	Criteria
5	Stakeholders regularly review the integrated curriculum and make recommendations and adjustments as needed.
4	There is evidence that personal, interpersonal, product, process, and system building skills are addressed in all courses responsible for their implementation.
3	Personal, interpersonal, product, process, and system building skills are integrated into one or more years in the curriculum.
2	A curriculum plan that integrates disciplinary learning, personal, interpersonal, product, process, and system building skills is approved by appropriate groups.
1	The need to analyze the curriculum is recognized and initial mapping of disciplinary and skills learning outcomes is underway.
0	There is no integration of skills or mutually supporting disciplines in the program.

Standard 4 — Introduction to Engineering

An introductory course that provides the framework for engineering practice in product, process, and system building, and introduces essential personal and interpersonal skills

Description

The introductory course, usually one of the first required courses in a program, provides a framework for the practice of engineering. This framework is a broad outline of the tasks and responsibilities of an engineer, and the use of disciplinary knowledge in executing those tasks. Students engage in the practice of engineering through problem solving and simple design exercises, individually and in teams. The course also includes personal and interpersonal skills knowledge, skills, and attitudes that are essential at the start of a program to prepare students for more advanced product, process, and system building experiences. For example, students can participate in small team exercises to prepare them for larger development teams.

Rationale

Introductory courses aim to stimulate students' interest in, and strengthen their motivation for, the field of engineering by focusing on the application of relevant core engineering disciplines. Students usually select engineering programs because they want to build things, and introductory courses can capitalize on this interest. In addition, introductory courses provide an early start to the development of the essential skills described in the CDIO Syllabus.

Rubric Standard 4

Scale	Criteria
5	The introductory course is regularly evaluated and revised, based on feedback from students, instructors, and other stakeholders.
4	There is documented evidence that students have achieved the intended learning outcomes of the introductory engineering course.
3	An introductory course that includes engineering learning experiences and introduces essential personal and interpersonal skills has been implemented.
2	A plan for an introductory engineering course introducing a framework for practice has been approved.
1	The need for an introductory course that provides the framework for engineering practice is recognized and a process to address that need has been initiated.
0	There is no introductory engineering course that provides a framework for practice and introduces key skills.

Standard 5 — Design-Implement Experiences*

A curriculum that includes two or more design-implement experiences, including one at a basic level and one at an advanced level

Description

The term design-implement experience denotes a range of engineering activities central to the process of developing new products and systems. Included are all of the activities described in Standard One at the Design and Implement stages, plus appropriate aspects of conceptual design from the Conceive stage. Students develop product, process, and system building skills, as well as the ability to apply engineering science, in design-implement experiences integrated into the curriculum. Design-implement experiences are considered basic or advanced in terms of their scope, complexity, and sequence in the program. For example, simpler products and systems are included earlier in the program, while more complex design-implement experiences appear in later courses designed to help students integrate knowledge and skills acquired in preceding courses and learning activities. Opportunities to conceive, design, implement, and operate products, processes, and systems may also be included in required co-curricular activities, for example, undergraduate research projects and internships.

Rationale

Design-implement experiences are structured and sequenced to promote early success in engineering practice. Iteration of design-implement experiences and increasing levels of design complexity reinforce students' understanding of the product, process, and system development process. Design-implement experiences also provide a solid foundation upon which to build deeper conceptual understanding of disciplinary skills. The emphasis on building products and implementing processes in real-world contexts gives students opportunities to make connections between the technical content they are learning and their professional and career interests.

Rubric Standard 5

Scale	Criteria
5	The design-implement experiences are regularly evaluated and revised, based on feedback from students, instructors, and other stakeholders.
4	There is documented evidence that students have achieved the intended learning outcomes of the design-implement experiences.
3	At least two design-implement experiences of increasing complexity are being implemented.
2	There is a plan to develop a design-implement experience at a basic and advanced level.
1	A needs analysis has been conducted to identify opportunities to include design-implement experiences in the curriculum.
0	There are no design-implement experiences in the engineering program.

Standard 6 — Engineering Workspaces

Engineering workspaces and laboratories that support and encourage hands-on learning of product, process, and system building, disciplinary knowledge, and social learning

Description

The physical learning environment includes traditional learning spaces, for example, classrooms, lecture halls, and seminar rooms, as well as engineering workspaces and laboratories. Workspaces and laboratories support the learning of product, process, and system building skills concurrently with disciplinary knowledge. They emphasize hands-on learning in which students are directly engaged in their own learning, and provide opportunities for social learning, that is, settings where students can learn from each other and interact with several groups. The creation of new workspaces, or remodeling of existing laboratories, will vary with the size of the program and resources of the institution.

Rationale

Workspaces and other learning environments that support hands-on learning are fundamental resources for learning to design, implement, and operate products, processes, and systems. Students who have access to modern engineering tools, software, and laboratories have opportunities to develop the knowledge, skills, and attitudes that support product, process, and system building competencies. These competencies are best developed in workspaces that are student-centered, user-friendly, accessible, and interactive.

Rubric Standard 6

Scale	Criteria
5	Evaluation groups regularly review the impact and effectiveness of workspaces on learning and provide recommendations for improving them.
4	Engineering workspaces fully support all components of hands-on, knowledge, and skills learning.
3	Plans are being implemented and some new or remodeled spaces are in use.
2	Plans to remodel or build additional engineering workspaces have been approved by the appropriate bodies.
1	The need for engineering workspaces to support hands-on, knowledge, and skills activities is recognized and a process to address the need has been initiated.
0	Engineering workspaces are inadequate or inappropriate to support and encourage hands-on skills, knowledge, and social learning.

Standard 7 — Integrated Learning Experiences*

Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process, and system building skills

Description

Integrated learning experiences are pedagogical approaches that foster the learning of disciplinary knowledge simultaneously with personal and interpersonal skills, and product, process, and system building skills. They incorporate professional engineering issues in contexts where they coexist with disciplinary issues. For example, students might consider the analysis of a product, the design of the product, and the social responsibility of the designer of the product, all in one exercise. Industrial partners, alumni, and other key stakeholders are often helpful in providing examples of such exercises.

Rationale

The curriculum design and learning outcomes, prescribed in Standards 2 and 3 respectively, can be realized only if there are corresponding pedagogical approaches that make dual use of student learning time. Furthermore, it is important that students recognize engineering faculty as role models of professional engineers, instructing them in disciplinary knowledge, personal and interpersonal skills, and product, process, and system building skills. With integrated learning experiences, faculty can be more effective in helping students apply disciplinary knowledge to engineering practice and better prepare them to meet the demands of the engineering profession.

Rubric Standard 7

Scale	Criteria
5	Courses are regularly evaluated and revised regarding their integration of learning outcomes and activities.
4	There is evidence of the impact of integrated learning experiences across the curriculum.
3	Integrated learning experiences are implemented in courses across the curriculum.
2	Course plans with learning outcomes and activities that integrate personal and interpersonal skills with disciplinary knowledge has been approved.
1	Course plans have been benchmarked with respect to the integrated curriculum plan.
0	There is no evidence of integrated learning of disciplines and skills.

Standard 8 — Active Learning

Teaching and learning based on active experiential learning methods

Description

Active learning methods engage students directly in thinking and problem solving activities. There is less emphasis on passive transmission of information, and more on engaging students in manipulating, applying, analyzing, and evaluating ideas. Active learning in lecture-based courses can include such methods as partner and small-group discussions, demonstrations, debates, concept questions, and feedback from students about what they are learning. Active learning is considered experiential when students take on roles that simulate professional engineering practice, for example, design-implement projects, simulations, and case studies.

Rationale

By engaging students in thinking about concepts, particularly new ideas, and requiring them to make an overt response, students not only learn more, they recognize for themselves what and how they learn. This process helps to increase students' motivation to achieve program learning outcomes and form habits of lifelong learning. With active learning methods, instructors can help students make connections among key concepts and facilitate the application of this knowledge to new settings.

Rubric Standard 8

Scale	Criteria
5	Evaluation groups regularly review the impact of active learning methods and make recommendations for continuous improvement.
4	There is documented evidence of the impact of active learning methods on student learning.
3	Active learning methods are being implemented across the curriculum.
2	There is a plan to include active learning methods in courses across the curriculum.
1	There is an awareness of the benefits of active learning, and benchmarking of active learning methods in the curriculum is in process.
0	There is no evidence of active experiential learning methods.

Standard 9 — Enhancement of Faculty Competence*

Actions that enhance faculty competence in personal and interpersonal skills, and product, process, and system building skills

Description

CDIO programs provide support for the collective engineering faculty to improve its competence in the personal and interpersonal skills, and product, process, and system building skills described in Standard 2. These skills are developed best in contexts of professional engineering practice. The nature and scope of faculty development vary with the resources and intentions of different programs and institutions. Examples of actions that enhance faculty competence include: professional leave to work in industry, partnerships with industry colleagues in research and education projects, inclusion of engineering practice as a criterion for hiring and promotion, and appropriate professional development experiences at the university.

Rationale

If engineering faculty are expected to teach a curriculum of personal and interpersonal skills, and product, process, and system building skills integrated with disciplinary knowledge, as described in Standards 3, 4, 5, and 7, they as a group need to be competent in those skills. Engineering professors tend to be experts in the research and knowledge base of their respective disciplines, with only limited experience in the practice of engineering in business and industrial settings. Moreover, the rapid pace of technological innovation requires continuous updating of engineering skills. The collective faculty needs to enhance its engineering knowledge and skills so that it can provide relevant examples to students and also serve as individual role models of contemporary engineers.

Rubric Standard 9

Scale	Criteria
5	Faculty competence in personal, interpersonal, product, process, and system building skills is regularly evaluated and updated where appropriate.
4	There is evidence that the collective faculty is competent in personal, interpersonal, product, process, and system building skills.
3	The collective faculty participates in faculty development in personal, interpersonal, product, process, and system building skills.
2	There is a systematic plan of faculty development in personal, interpersonal, product, process, and system building skills.
1	A benchmarking study and needs analysis of faculty competence has been conducted.
0	There are no programs or practices to enhance faculty competence in personal, interpersonal, product, process, and system building skills.

Standard 10 — Enhancement of Faculty Teaching Competence

Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning

Description

A CDIO program provides support for faculty to improve their competence in integrated learning experiences (Standard 7), active and experiential learning (Standard 8), and assessing student learning (Standard 11). The nature and scope of faculty development practices will vary with programs and institutions. Examples of actions that enhance faculty competence include: support for faculty participation in university and external faculty development programs, forums for sharing ideas and best practices, and emphasis in performance reviews and hiring on effective teaching methods.

Rationale

If faculty members are expected to teach and assess in new ways, as described in Standards 7, 8, and 11, they need opportunities to develop and improve these competencies. Many universities have faculty development programs and services that might be eager to collaborate with faculty in CDIO programs. In addition, if CDIO programs want to emphasize the importance of teaching, learning, and assessment, they must commit adequate resources for faculty development in these areas.

Rubric Standard 10

Scale	Criteria
5	Faculty competence in teaching, learning, and assessment methods is regularly evaluated and updated where appropriate.
4	There is evidence that the collective faculty is competent in teaching, learning, and assessment methods.
3	Faculty members participate in faculty development in teaching, learning, and assessment methods.
2	There is a systematic plan of faculty development in teaching, learning, and assessment methods.
1	A benchmarking study and needs analysis of faculty teaching competence has been conducted.
0	There are no programs or practices to enhance faculty teaching competence.

Standard 11 — Learning Assessment*

Assessment of student learning in personal and interpersonal skills, and product, process, and system building skills, as well as in disciplinary knowledge

Description

Assessment of student learning is the measure of the extent to which each student achieves specified learning outcomes. Instructors usually conduct this assessment within their respective courses. Effective learning assessment uses a variety of methods matched appropriately to learning outcomes that address disciplinary knowledge, as well as personal and interpersonal skills, and product, process, and system building skills, as described in Standard 2. These methods may include written and oral tests, observations of student performance, rating scales, student reflections, journals, portfolios, and peer and self-assessment.

Rationale

If we value personal and interpersonal skills, and product, process, and system building skills, and incorporate them into curriculum and learning experiences, then we must have effective assessment processes for measuring them. Different categories of learning outcomes require different assessment methods. For example, learning outcomes related to disciplinary knowledge may be assessed with oral and written tests, while those related to design-implement skills may be better measured with recorded observations. Using a variety of assessment methods accommodates a broader range of learning styles, and increases the reliability and validity of the assessment data. As a result, determinations of students' achievement of the intended learning outcomes can be made with greater confidence.

Rubric Standard 11

Scale	Criteria
5	Evaluation groups regularly review the use of learning assessment methods and make recommendations for continuous improvement.
4	Learning assessment methods are used effectively in courses across the curriculum.
3	Learning assessment methods are implemented across the curriculum.
2	There is a plan to incorporate learning assessment methods across the curriculum.
1	The need for the improvement of learning assessment methods is recognized and benchmarking of their current use is in process.
0	Learning assessment methods are inadequate or inappropriate.

Standard 12 — Program Evaluation

A system that evaluates programs against these twelve standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement

Description

Program evaluation is a judgment of the overall value of a program based on evidence of a program's progress toward attaining its goals. A CDIO program should be evaluated relative to these 12 CDIO Standards. Evidence of overall program value can be collected with course evaluations, instructor reflections, entry and exit interviews, reports of external reviewers, and follow-up studies with graduates and employers. The evidence can be regularly reported back to instructors, students, program administrators, alumni, and other key stakeholders. This feedback forms the basis of decisions about the program and its plans for continuous improvement.

Rationale

A key function of program evaluation is to determine the program's effectiveness and efficiency in reaching its intended goals. Evidence collected during the program evaluation process also serves as the basis of continuous program improvement. For example, if in an exit interview, a majority of students reported that they were not able to meet some specific learning outcome, a plan could be initiated to identify root causes and implement changes. Moreover, many external evaluators and accreditation bodies require regular and consistent program evaluation.

Rubric Standard 12

Scale	Criteria
5	Systematic and continuous improvement is based on program evaluation results from multiple sources and gathered by multiple methods.
4	Program evaluation methods are being used effectively with all stakeholder groups.
3	Program evaluation methods are being implemented across the program to gather data from students, faculty, program leaders, alumni, and other stakeholders.
2	A program evaluation plan exists.
1	The need for program evaluation is recognized and benchmarking of evaluation methods is in process.
0	Program evaluation is inadequate or inconsistent.