CONCEIVE DESIGN IMPLEMENT OPERATE

# The CDIO approach

## for engineering education development

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# Kristina Edström


## Engineer & Educational developer

- M. Sc. in Engineering, Chalmers & PhD in Technology and Learning, KTH
- Associate Professor in *Engineering Education Development* at KTH Royal Institute of Technology, Stockholm, Sweden
- 700 participants in the course *Teaching and Learning in Higher Education*, 7.5 ECTS, customized for KTH faculty, 2004-2012
- Director of Educational Development at Skolkovo Institute of Science and Technology, Moscow, 2012-2013
- CDIO Initiative for reform of engineering education since 2001
- SEFI Administrative Council, 2010-2013
- Editor-in-Chief of the *European Journal of Engineering Education*

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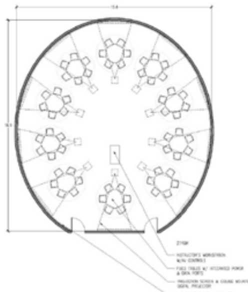
### Some publications

- 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.
- Edström, K. (2017). The role of CDIO in engineering education research: Combining usefulness and scholarliness. *European Journal of Engineering Education.*
- Edström,K. (2018). Academic and professional values in engineering education: Engaging with the past to explore a persistent tension. *Engineering Studies.*



# LET’S START WITH AN EXAMPLE

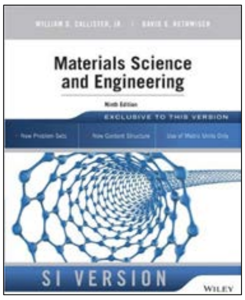
## LET’S START WITH AN EXAMPLE

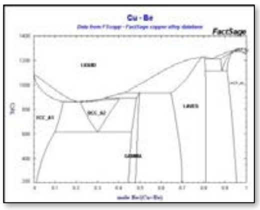
### COURSE LEVEL

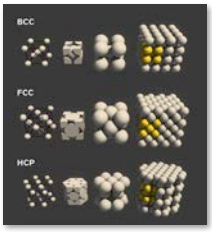
- A course in basic materials science (at Chalmers)

# 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**

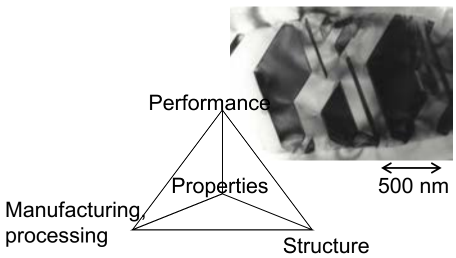
"Materials engineers distinguish themselves from mechanical engineers by their focus on the internal structure and processing of materials, specifically at the micro- and nano-scale."

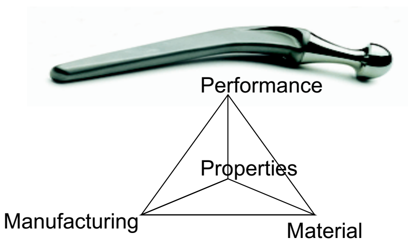
Flemings & Cahn

**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…."

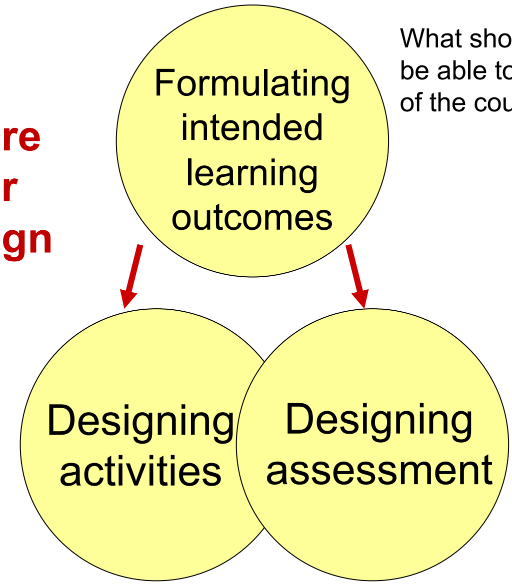
Östberg




[Professor Maria Knutson Wedel, Chalmers]

## Intended learning outcomes are the basis for course design




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

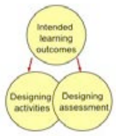
Constructive alignment [Biggs]

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

How should the students demonstrate that they fulfil the learning outcomes?

**A course in Basic Materials Science**

## 1. Changing the learning objectives




### Before
**disciplinary knowledge in itself**

…describe crystal structures of some metals…

…interpret phase diagrams…

…explain hardening mechanisms…

...describe heat treatments…

### Now
**performances of understanding**

…select materials based on considerations for functionality and sustainability

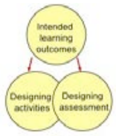
...explain how to optimize material dependent processes (e.g. casting, forming, joining)

...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**



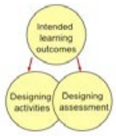

# 2. Changing the learning activities

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**




# 3. Redesigning 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** – integrating the parts of the course

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]

Not just about getting a good mix of Project-based and Subject-based courses

” ” ”

**What view of knowledge is the teaching in your programmes and courses based on?**

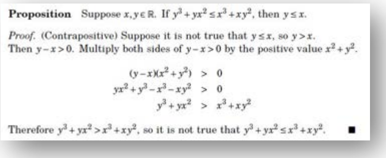
**The disciplinary knowledge in itself** **or** **What an engineer can do with that understanding**

# LET’S TAKE ANOTHER EXAMPLE

## PROGRAMME LEVEL

- Integration of computational mathematics (in the Mechanical Engineering programme at Chalmers)

Traditional mathematics



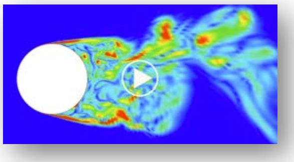
**Proposition** Suppose $x, y \in \mathbb{R}$. If $y^3 + yx^2 \le x^3 + xy^2$, then $y \le x$.

*Proof.* (Contrapositive) Suppose it is not true that $y \le x$, so $y > x$. Then $y - x > 0$. Multiply both sides of $y - x > 0$ by the positive value $x^2 + y^2$.

$$\begin{aligned} (y-x)(x^2+y^2) &> 0 \\ yx^2 + y^3 - x^3 - xy^2 &> 0 \\ y^3 + yx^2 &> x^3 + xy^2 \end{aligned}$$

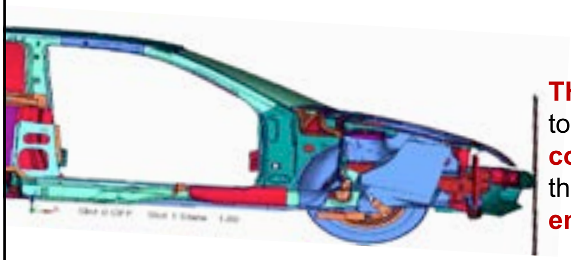
Therefore $y^3 + yx^2 > x^3 + xy^2$, so it is not true that $y^3 + yx^2 \le x^3 + xy^2$. ■

Computational mathematics



## Integrating computational mathematics

**Mechanical Engineering at Chalmers, Sweden**



**THE AIM**
to **modernize the mathematical content** while also strengthening the **connection between engineering and mathematics**

Students need to:

- learn to solve more **general, real-world problems**
- spend less time *"solving oversimplified problems that can be expressed analytically and with solutions that are already known in advance"*
- work on **complete problems**
  - setting up a mathematical **model** and solving it,
  - **simulation** of the system,
  - using **visualisation** to assess the correctness of the model and the solution and compare with physical reality

(Enelund et al. 2011)

## Programme-driven approach with collegial collaboration

This was not framed as a task for mathematics teachers to solve within the mathematics courses!

Making **connections to mathematics in engineering subjects** was at least as important as making **connections to engineering in mathematics**

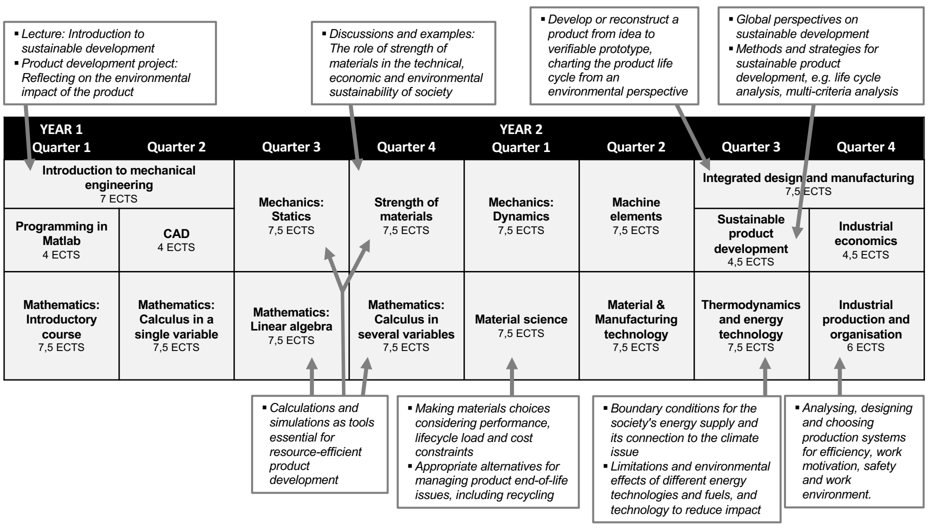
# Integrating computational mathematics

Interventions in the programme:

- **New basic math courses** including a an introduction to programming in a technical computing language and environment (Matlab)
- Production of **new teaching materials** (since few textbooks take advantage of the development in computing)
- **Integration of relevant mathematics topics in fundamental engineering courses** such as mechanics and control theory
- **Cross-cutting exercises, assignments and team projects** shared between the mechanics and strengths of materials courses and mathematics courses

Program driven development

# Integration of sustainable development



” ” ”

**What kinds of problems / improvements are best addressed in a programme level approach?**

## BUT WHAT WERE THESE CASES EXAMPLES OF?

## CDIO is a community for developing engineering education

The CDIO Initiative

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- **The CDIO Initiative** started in 2000 with 4 partners: MIT, KTH Royal Institute of Technology, Chalmers, and Linköping University
- Soon other institutions expressed an interest in joining
- Today **about 160 CDIO Collaborators** worldwide

## The international CDIO community

**North America**
- Arizona State University
- California State University, Northridge
- 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
- Santo Tomás University
- School of Engineering of Antioquia (EIA)
- UNISAL – Salesian University Center of Sao Paulo
- UNITEC Laureate International Universities
- Universidad Católica de la Santísima Concepción
- Universidad de Chile
- Universidad de Los Lagos
- Universidad de Santiago de Chile
- Universidad del Quindío
- Universidad ICESI, Cali
- Universidad Nacional de Colombia, Bogota
- Universidad Tecnológica de Chile INACAP

**Sweden**
- Blekinge tekniska högskola
- Chalmers tekniska högskola*
- Högskolan i Jönköping
- Högskolan Kristianstad
- Kungl. Tekniska högskolan*
- Linköpings universitet*
- Linnéuniversitetet
- Luleå tekniska universitet
- Umeå universitet
- Högskolan i Skövde
- Högskolan Väst

See www.cdio.org

**Asia**
- Beijing Institute of Petrochemical Technology (BIPT)
- Beijing Jiaotong University
- Bulacan State University
- Chengdu University of Information Technology
- Chulalongkorn University (Faculty of Engineering)
- Dalat University
- Dalian Neusoft University of Information
- Duy Tan University
- Feng Chia University
- FPT Education
- Inje University
- Kanazawa Institute of Technology
- Kanazawa Technical College
- Mongolian University of Science and Technology
- Nanyang Polytechnic
- National Institute of Technology, Kisarazu College
- Politeknik Ungku Omar
- 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)
- Vel Tech Dr.RR & Dr.SR Technical University
- Vietnam National University
- Yanshan University

**Australia:**
- Australasian Association for Engineering Education (Affiliated organization)
- Chisholm Institute, Centre for Integrated Engineering & Science
- Curtin University
- Queensland University of Technology
- Royal Melbourne Institute of Technology - RMIT
- University of Auckland
- University of Sydney
- University of the Sunshine Coast

**Africa**
- University of Pretoria
- ESPRIT, Tunisia

**Europe**
- Aalborg University
- Aarhus University
- 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 (EAH Jena)
- Escola Tecnica Superior d'Enginyeria Quimica (ETSEQ)
- ESPRIT
- Gdansk University of Technology
- Ghent University
- Graduate School of Engineering CESI
- Group T - International University College Leuven
- Hague University of Applied Sciences
- Hochschule Wismar
- IMT Atlantique (formerly Telecom Bretagne & EMN)
- Instituto Superior de Engenharia do Porto
- Israel Institute for Empowering Ingenuity
- Kazan Federal University
- Lahti University of Applied Sciences
- Lapland University of Applied Sciences
- Metropolia University of Applied Sciences
- Moscow Aviation Institute
- Moscow Institute of Physics and Technology (MIPT)
- National Research Nuclear University - NRNU MEPhI
- North-Eastern Federal University
- Novia University of Applied Sciences
- **NTNU - Norweigian University of Science and Technology**
- Orel State University
- Politecnico di Milano
- Reykjavik University
- RWTH Aachen
- Saint Petersburg State University of Aerospace Instrumentation
- Savonia University of Applied Sciences
- Seinäjoki University of Applied Sciences
- Siberian Federal University
- Skolkovo Institute for Science and Technology
- Surgut State University, SurSU
- Tampere University of Applied Sciences (TAMK)
- Technical University of Denmark
- Technical University of Madrid
- Tomsk Polytechnic University
- Tomsk State University of Control Systems and Radioelectronics (TUSUR)
- Turku University of Applied Sciences
- Universitat Politècnica de Catalunya (Telecom BCN)
- University of Turku
- University of Twente
- Ural Federal University
- Vilniaus Kolegija/University of Applied Sciences
- Østfold University College

## Annual International CDIO Conference


- **16th International CDIO Conference**
  8, 9 and 10 June 2020
  13.00-16.00 Online

Free for participants!

se www.cdio.org

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
2018 Kanazawa, Japan
2019 Aarhus University, Denmark


The 16th International CDIO Conference
*SUSTAINING THE CHANGE*
June 8 – June 12, 2020
Chulalongkorn University (CU) &
Rajamangala University of Technology Thanyaburi (RMUTT)
BANGKOK, THAILAND http://www.cdio2020.chula.ac.th/

CALL FOR PAPERS
August 2019

The CDIO approach (www.cdio.org) is an innovative educational framework for producing the next generation of engineers. It is a framework for providing students with an education stressing engineering fundamentals set in the context of Conceiving — Designing — Implementing — Operating (CDIO) real-world systems and products.

CDIO collaborators recognize that engineering education is acquired through programs of varying lengths and stages in a variety of institutions and that educators in all parts of this spectrum can learn from practice elsewhere. Several times each year, CDIO collaborating institutions, engineering educators and researchers gather to exchange ideas and experiences, review developments, assess and further refine the CDIO approach.

The CDIO Initiative welcomes your ideas and invites proposals for papers, working groups, workshops and roundtables at the 16th International CDIO Conference. The conference takes place in Bangkok, Thailand on June 8 (afternoon) – June 12, 2020. Additional information on the conference is available at www.cdio2020.chula.ac.th

The main theme of the conference is "Sustaining the Change". Proposals for contributions are welcome on topics relevant to the CDIO approach and the conference theme. For Paper contributions, the presentation formats are Podium Presentations and Poster Presentations. Workshops and Roundtable Discussions are contribution categories that do not require a full paper. Please see the sections below for more details about the contribution categories and presentation formats.

**Call for Papers**
**see www.cdio.org**

**Deadline for abstracts**
**15 November 2020**

## CDIO is a community for developing engineering education

It is based on an **idea** of what students should learn to become good engineers
(who can develop technology, or Conceive, Design, Implement and Operate products, processes and systems)

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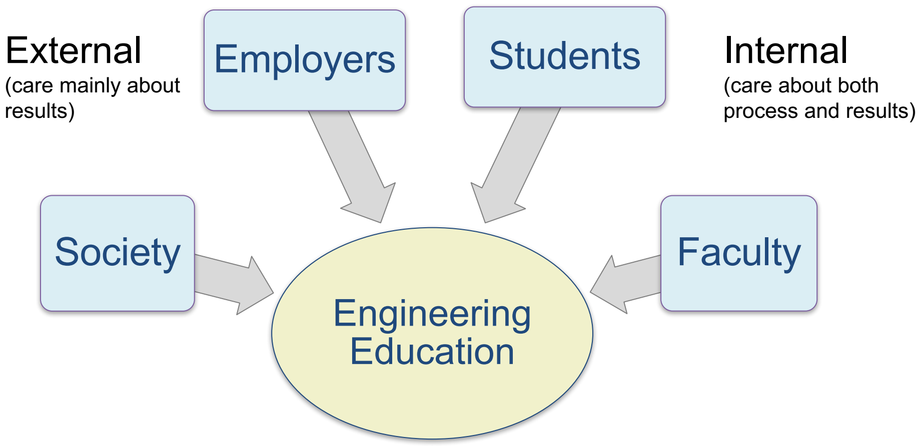
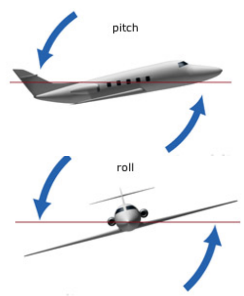
**CDIO Standard 1 – The context**
Adoption of the principle that product, process, and system lifecycle development and deployment – Conceiving, Designing, Implementing and Operating – are the context for engineering education.

## Stakeholder perspectives




## An education *about* technology




**NECESSARY BUT NOT SUFFICIENT**

## An education *in* engineering – *becoming* an engineer

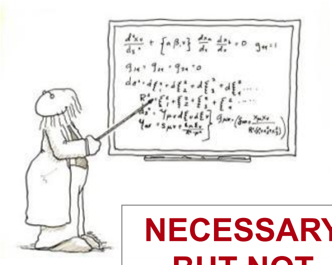
**Conceive**: customer needs, technology, enterprise strategy, regulations; and conceptual, technical, and business plans

**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 real 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***

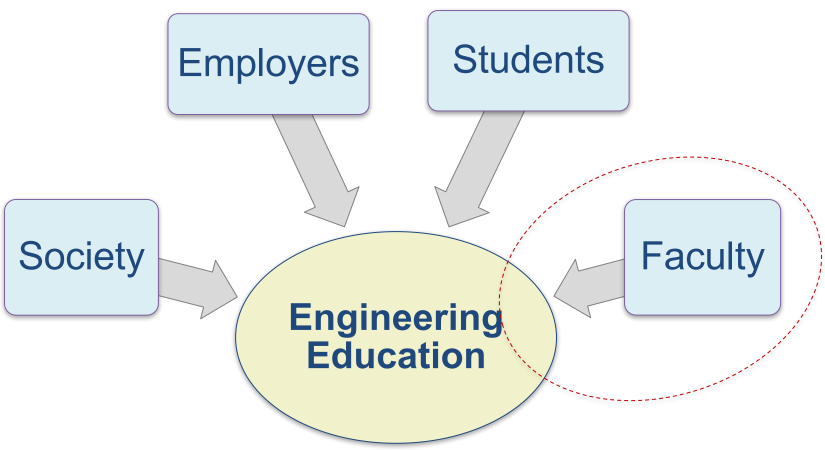
**NECESSARY BUT NOT SUFFICIENT**

**Educate for the context of *Engineering***

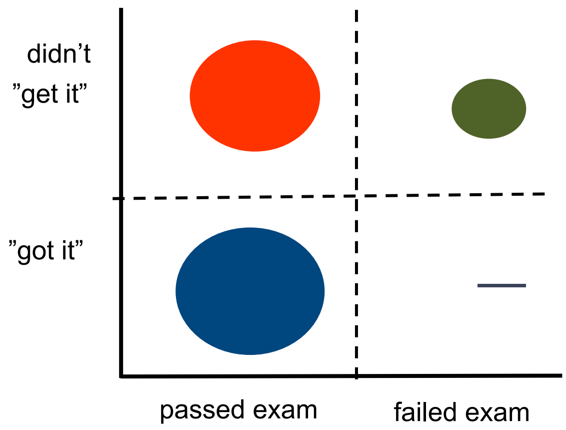
**CDIO Standard 1 – The context**
Adoption of the principle that product, process, and system lifecycle development and deployment – Conceiving, Designing, Implementing and Operating – are the context for engineering education.

*Engineers who can engineer!*

## And when 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

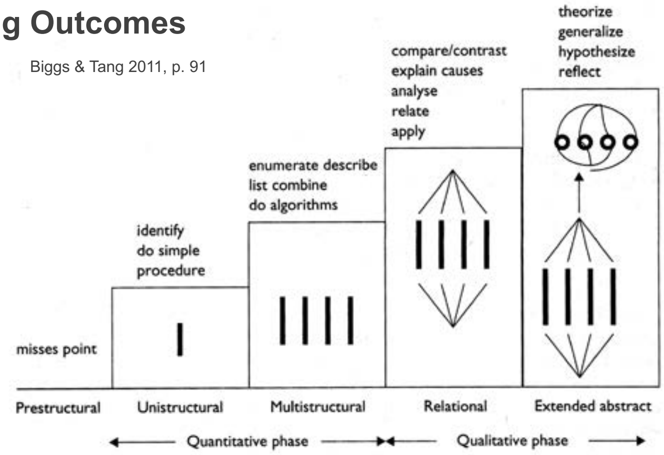
| | |
|---|---|
| Judge *Bedöma* | To be able to critically evaluate multiple solutions and select an optimum solution |
| Solve *Problemlösning* | Characterize, analyze, and synthesize to model a system (provide appropriate assumptions) |
| Explain *Förklara* | Be able to state the process/outcome/concept in their own words |
| Compute *Räkna typtal* | Follow rules and procedures (substitute quantities correctly into equations and arrive at a correct result, "plug & chug") |
| Define *Återge* | 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.]

# Quality of student learning
## The SOLO Taxonomy

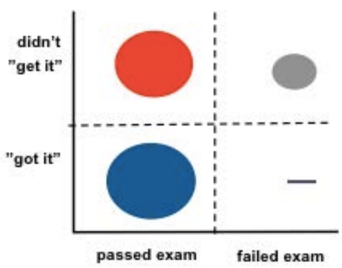
### Structure of Observed Learning Outcomes

Biggs & Tang 2011, p. 91




” ” ”

## What tools or language do you normally use for discussing the quality of learning?




| | |
|---|---|
| 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 |

## CDIO is a community for developing engineering education

It is a methodology

**The 12 CDIO Standards**

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## 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.

# National level learning outcomes

For Master of Science in Engineering, students must demonstrate:

*Knowledge and understanding*

- knowledge of the scientific basis and proven experience of their chosen area of engineering, together with insight into current research and development work; and
- 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*

- 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;
- an ability to create, analyse and critically evaluate different technical solutions;
- an ability to plan and, using appropriate methods, carry out advanced tasks within specified parameters;
- an ability to integrate knowledge critically and systematically and to model, simulate, predict and evaluate events even on the basis of limited information;
- 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;
- an ability to engage in teamwork and cooperation in groups of varying composition; and
- 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.

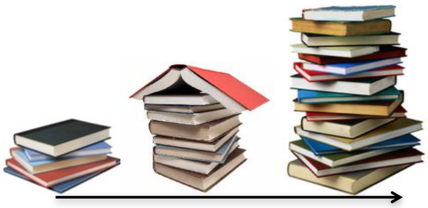
*Judgement and approach*

- 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;
- 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
- an ability to identify their need of further knowledge and to continuously upgrade their capabilities.

The strategy of CDIO is
integrated learning
of knowledge and skills

!

# Standard 3 – Integrated curriculum
## Integrating the two learning processes



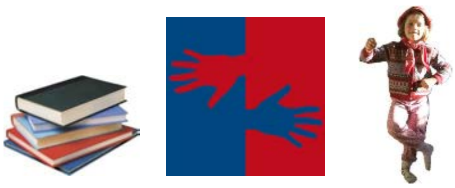
Acquisition of technical knowledge

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
- Real problems, in a 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

## 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

- 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

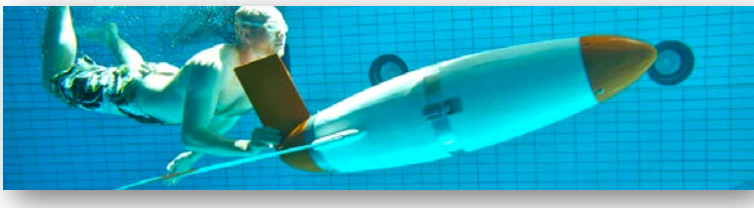
**How to teach these courses sustainably**

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.

## 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



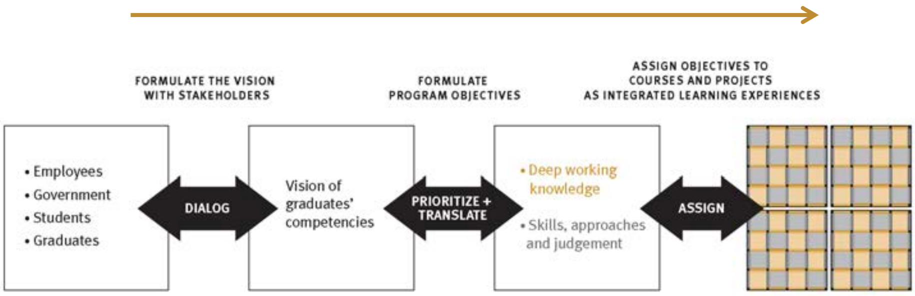
# Integrated curriculum – main ideas

### Start by forming a vision
- Form a vision for the graduate in dialogue with stakeholders
- Prioritise and translate to learning outcomes for the programme

### Integrated learning
- Connection knowledge and understanding **with** skills, approaches and judgement
- Learning in the logic of disciplines (theory) and the logic of problems (practice)

### Connection and progression
- The contribution of the course is made explicit (connection between course and program)
- Connection between courses, progression
- Program driven course development

# Integrated Curriculum in a nutshell



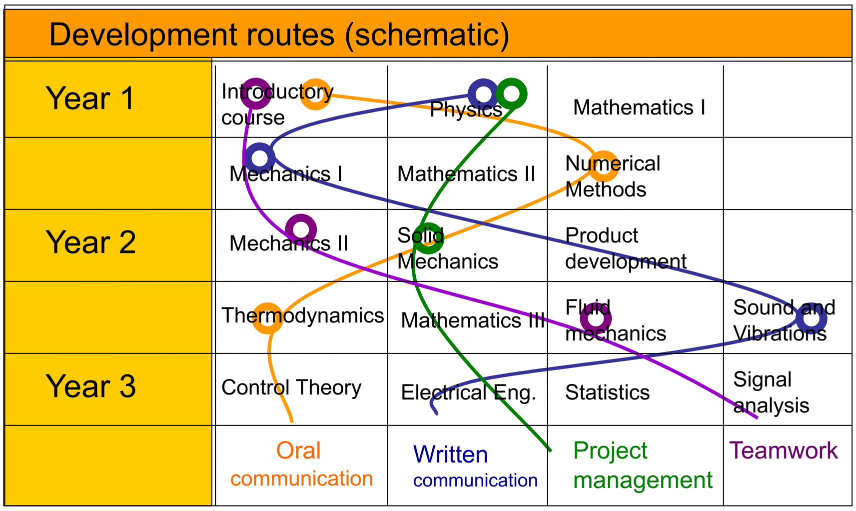

(Crawley, Hegarty, Edström and Garcia Sanchez, forthcoming 2020)

# INTEGRATION & PROGRESSION


## Dimensions of progression

- 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)

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




## Example: Communication skills in Lightweight design & FEM modelling

In this course, **communication** 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]

## 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**

"When students come to my course I want them to be able to…"

"When students leave my course they will be able to… because I think this is necessary input for course X…"

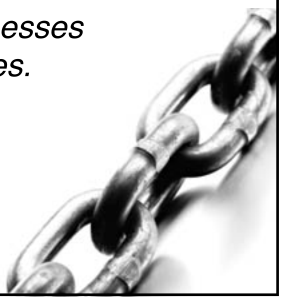
## The curriculum has 2 logical links

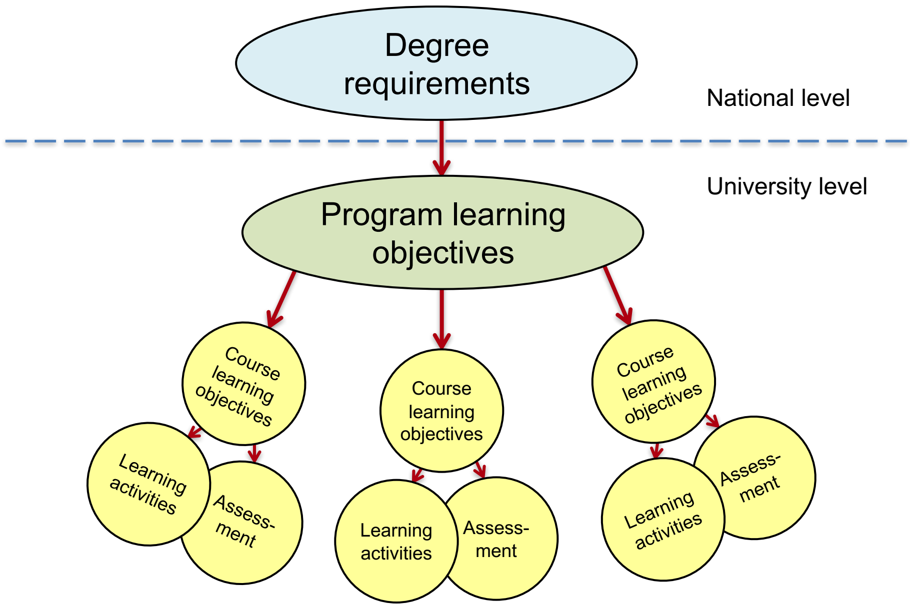
The strength of the chain – the extent to which graduates will actually meet the program learning objectives – hinges on:

- **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.*





# Bureaucracy warning


- Just because it looks perfect on paper, does it work?
- When are we developing the programme and when are we feeding the control systems?
- How are we using our capacity for development?
- How should our best teachers spend their time?

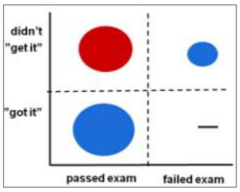
# Anyone can improve a course if it means that the teacher works 100 hours more

That is not a valid solution…

**This is about how to get better student learning from the same 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.

## Constructive alignment - applied




Formulating intended learning outcomes

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

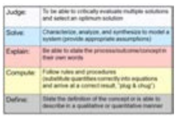
Designing activities

Designing assessment

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

How should the students demonstrate that they fulfil the learning outcomes?

## Constructive alignment - applied



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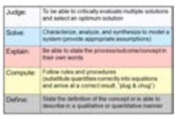
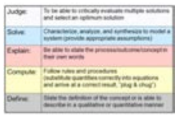


Designing activities

Designing assessment



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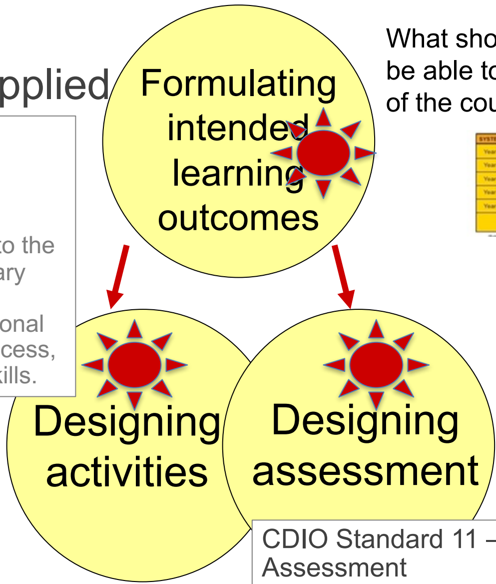



What should the students be able to do as a result of the course?

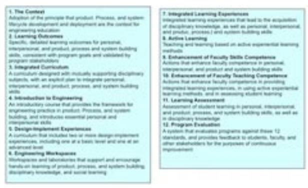
**CDIO Standard 7 – Integrated Learning Experiences**
Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process, and system building skills.

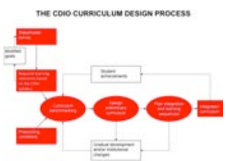
**CDIO Standard 8 – Active Learning**
Teaching and learning based on active and experiential learning methods

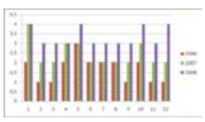
**CDIO Standard 11 – Learning Assessment**
Assessment of student learning in personal and interpersonal skills, and product, process, and system building skills, as well as in disciplinary knowledge.

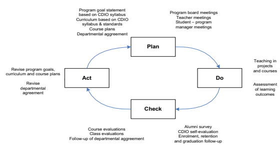
## CDIO-based quality assurance system

- CDIO syllabus
  – ***WHAT***
- CDIO standards
  – ***HOW***
- CDIO curriculum design process
  – ***from WHAT to HOW***
- CDIO standards self-evaluation
  – ***HOW WELL***

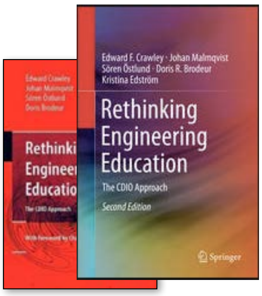






# In the book shelf




**Book in 2nd edition**

- Crawley, E., Malmqvist, J., Östlund, S., Brodeur, D., Edström, K., *Rethinking Engineering Education, The CDIO Approach*. Springer, 2014.

(Also in Chinese, Russian, Vietnamese)

**Shorter introduction**

- Edström, K., & Kolmos, A. (2014). PBL and CDIO: complementary models for engineering education development. *European Journal of Engineering Education*, 39(5), 539-555.

**Chalmers program development**

- Malmqvist, J., Bankel, J., Enelund, M., Gustafsson, G., & Knutson Wedel, M. (2010). Ten Years of CDIO - Experiences from a Long-term Education Development Process. *Proceedings of the 6th International CDIO Conference*. École Polytechnique de Montréal, Québec, Canada.
- Enelund, M., Larsson, S., & Malmqvist, J. (2011). Integration of Computational Mathematics Education in the Mechanical Engineering Curriculum. *Proceedings of the 7th International CDIO Conference*, Copenhagen, Denmark.
- Enelund, M., Knutson Wedel, M., Lundqvist, U., & Malmqvist, J. (2013). Integration of education for sustainable development in the mechanical engineering curriculum. *Australasian Journal of Engineering Education*, 19(1), 51-62.

**See also**

- Edström, K. (2017). The role of CDIO in engineering education research: Combining usefulness and scholarliness, *European Journal of Engineering Education*.
- Edström, K. (April 2018). Academic and professional values in engineering education: Engaging with history to explore a persistent tension. *Engineering Studies*, 10(1), 38-65.
- Edström, K. (2019). Integrating the academic and professional values in engineering education – ideals and tensions. In Geschwind, L., Larsen, K., & Broström, A. (Eds.) *Technical Universities - Past, present and future*. Springer Higher Education Dynamics.

# What is CDIO?

1. **A community** to develop the concept & share experiences
   **The CDIO Initiative**
2. **An idea** that we should educate
   **engineers who can actually engineer**
3. **A methodology** for curriculum development
   **The 12 CDIO Standards**

cdio
CONCEIVE DESIGN IMPLEMENT OPERATE