The CDIO framework for engineering education

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Outline

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• CDIO in general
• The CDIO framework in some detail
• Case study
Main message

Every graduating engineer should be able to:

”Conceive-Design-Implement-Operate complex value-added engineering products, processes and systems in a modern, team-based environment”

Crawley, Malmqvist, Östlund, Brodeur, and Edström, “Rethinking Engineering Education. The CDIO Approach.” Springer, page 50
Background
Linköping University

- 27,000 students
- 58.4 degrees North
Myself

- Professor in Automatic Control.
- For twelve years chairman of the Program Board for education programs within electrical engineering, physics, mathematics.
- Involved in the CDIO Initiative since the start.
- CDIO-coordinator within Linköping University.
- Research interests: Industrial robots.
- ............................................
CDIO in general
What is CDIO?

• An international collaboration network - The CDIO Initiative.
• A framework for development of engineering education.
• An acronym – Conceive, Design, Implement, and Operate
The CDIO Initiative

- Started in 2000.
- Four original universities: MIT, Linköping University, Chalmers Institute of Technology, and Royal Institute of Technology (KTH),
- Now, more than one hundred collaborating universities from all parts of the world.
- Annual International CDIO Conference
- Results documented in the CDIO Book and several publications
- Web site www.cdio.org
The CDIO framework in some detail
Main components

• A definition of the role of an engineer.
• Clearly defined and documented goals for the desired knowledge and skills of an engineer - CDIO Syllabus.
• Clearly defined and documented goals for the properties of the engineering programs - CDIO Standards.
Recall ....

Every graduating engineer should be able to:

”Conceive-Design-Implement-Operate complex value-added engineering products, processes and systems in a modern, team-based environment”
Question I

Which knowledge and skills are expected from an engineer?
A good understanding of engineering science fundamentals
   Mathematics (including statistics)
   Physical and life sciences
   Information technology (far more than "computer literacy")

A good understanding of design and manufacturing processes
   (i.e., understands engineering)

A multi-disciplinary, systems perspective.

A basic understanding of the context in which engineering is practiced
   Economics (including business practices)
   History
   The environment
   Customer and societal needs

Good communication skills.
   Written, oral, graphic and listening

High ethical standards

An ability to think both critically and creatively - independently and cooperatively

Flexibility. The ability and self-confidence to adapt to rapid or major change

Curiosity and a desire to learn for life

A profound understanding of the importance of teamwork
The CDIO Syllabus

A structured way to specify the desired knowledge and skills of an engineer:

1. Disciplinary knowledge and reasoning
2. Personal and professional skills and attributes.
3. Interpersonal skills: Teamwork and communication
4. Conceiving, designing, implementing and operating systems in the enterprise, societal, and environmental context – The innovation process

+ subsections and sub-subsections
Uses of the CDIO Syllabus

• A reference frame for defining goals for programs and courses.
• Basis for stakeholder survey.
• Documents and experiences available.
• …………

Comment:
• Strong resemblance with the ABET criteria.
Question II

How should an engineering education program be designed in order to lead to the desired knowledge and skills?
The CDIO Standards

A structured way to specify desired properties of an engineering program:

- Standard 1 - CDIO as Context.
- Standard 2 - CDIO Syllabus Outcomes.
- Standard 3 - Integrated Curriculum.
- Standard 4 - Introduction to Engineering.
- Standard 5 - Design-Build Experiences.
- Standard 6 - CDIO Workspaces.
The CDIO Standards (cont.)

- Standard 7 - Integrated Learning Experiences.
- Standard 8 - Active Learning.
- Standard 9 - Enhancement of Faculty CDIO Skills.
- Standard 10 - Enhancement of Faculty Teaching Skills.
- Standard 11 - CDIO Skills Assessment.
- Standard 12 - CDIO Program Evaluation.
Uses of the CDIO Standards

- Self evaluation of your own education program.
- Indication of progress in program development.
- Documents and experiences available.
- ..........................
Comments

• Most of the components in the framework have existed for many years.
• The key feature of the CDIO framework is that they have been put in a structure.
• ..........................
Case study - CDIO implementation within the Applied Physics and Electrical Engineering Program
General educational structure in Sweden

**Research level** (3rd level)
- Licentiate degree (2 years)
- PhD degree (4 years)

**Advanced Level** (2nd level)
- Master’s degree (2 years)

**Basic level** (1st level)
- Bachelor’s degree (3 years)

Diagram:
The Applied Physics and Electrical Engineering program

- Five years (300 ECTS credits)
- 270 credits courses + 30 credits Master’s Thesis.
- Three years (i.e. 180 ECTS credits) of mandatory courses: 75 credits mathematics, 40 credits electrical engineering, 40 credits physics and 15 credits computer science.
Specializations during year four and five

- Engineering mathematics
- Financial mathematics
- Theory, modeling and visualization
- Materials and nano-physics
- Electronics
- System on Chip
- Mechatronics
- Control and information systems
- Signal and image processing
- Biomedical engineering
- Communication
An important part of the CDIO implementation –
A sequence of project courses

The project model LIPS is used in all project courses
Introductory course

Goals:
- Introduction to engineering
- First experience in team work
- Introduction to and use of the project model
- First design-build experience
- Motivation for further studies
- Communication training

Organization:
- 6 ECTS credit, fall year one
- Introductory lectures
- Project
- Project conference
Introductory course

Outomes:

• Given for the first time fall 2002.
• 150 students/year, approx. 25 project groups/year
• Mainly good results
• Differences in project complexity
Fifth year courses

Organization:
- Ten courses (five different departments)
- 12 ECTS credit, fall semester year five
- 9 ECTS credits technical part + 3 ECTS credits entrepreneurship

Outcomes:
- Given for the first time spring 2004.
- Approximately 150 students
Fifth year courses

- Applied mathematics, project course
- Design and manufacturing of sensor chips
- Computational physics
- Mixed signal processing systems
- System design
- VLSI Design project
- Images and graphics, project course
- Automatic control, project course
- Biomedical engineering, project course
- Communication systems, project course
Electronics project course
Learning outcomes

After the course the student shall be able to:

- **Integrate knowledge** acquired in previous courses by designing and building a computer controlled device (Section 1 of the CDIO Syllabus)
- **Use a structured tool for project management** extensively, including to write and follow-up project and time plans and other relevant documents (Sections 4.3-4.6)
- Participate in **engineering teamwork** in an industry like context, and to actively contribute to a well functioning project group (Section 3.1)
- **Practice various engineering skills**, such as measurement technology, trouble shooting, system thinking, structured design, modern development tools etc. (E.g. Sections 1.2-1.3, 2.1-2.3)
- **Present project results orally and in written** documentation. (Section 3.2)
- **Model digital systems** using the hardware description language (VHDL) (Section 1.3)
A challenge! From idea to finished product
Workspaces and active learning
Structure of the project work
The project model LIPS

**Before**
- Idea
- What?
- Requirements
- How?
- Plans
- tollgate
- milestone

**During**
- Design
- Code
- Circuit diagrams etc.
- Evaluation
- System test
- Integration
- Test
- n

**After**
- Delivery
- Final report
- Evaluation

**Legend**
- 

**Notations**
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Week 8-14 - execution

During

From Before

Design

TG3

Implementation

TG4

System test

TG5

Design spec.

Test spec.

Project plan new version

tollgates

specifications

plans

customer doc.

reports

protocols

Technical documentation

User-manual

Test-protocol

Status reports, time reports and meeting minutes
Week 8-14 - execution

During

From Before

Design

TG3

Implementation

TG4

System test

TG5

Design spec.

Project plan

new version

8 times

Examination

Technical documentation

User manual

Status reports, time reports and meeting minutes

tollgates

specifications

plans

customer doc.

reports

protocols
The last week - delivery

Examination

- Technical documentation
- Seminars
- Demonstrations and competitions
- Project reflections
- Grade: Pass/Fail
See also ....

And ..... 

https://youtu.be/N5_tMeEpJaA
Summary
Every graduating engineer should be able to:

”Conceive-Design-Implement-Operate complex value-added engineering products, processes and systems in a modern, team-based environment”
Aurora Borealis over Linköping

Thank you

Photo: Jens Birch, prof Thin film physics