THE CDIO APPROACH TO ENGINEERING EDUCATION: 
2. Designing An Integrated Curriculum 

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SESSION TWO OBJECTIVES

- Explain the rationale for an integrated curriculum
- Plan ways to benchmark an existing curriculum
- Describe the process for designing and implementing an integrated curriculum
CDIO IS NOT A COOKIE CUTTER APPROACH

CDIO is a *reference model*

Everything has to be *translated-transformed* to fit the context and conditions of each university / program

Take what you want to use, transform it as you wish, give it a new name

CDIO provides a toolbox for working through the process

Local faculty ownership is key
CURRICULUM MODELS

A strict disciplinary curriculum
Organized around disciplines, with no explicit introduction of skills

An integrated curriculum
Organized around disciplines, but with skills and projects interwoven

A problem-based curriculum
Organized around problems, but with disciplines interwoven

An apprenticeship model
Based on projects, with no organized introductions of disciplines

(Disciplines run vertically; projects and skills run horizontally.)
## SYSTEMATIC PROGRESSION OF SKILLS DEVELOPMENT

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Course A</th>
<th>Course B</th>
<th>Course C</th>
<th>Course D</th>
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</thead>
<tbody>
<tr>
<td>Year 2</td>
<td>Course E</td>
<td>Course F</td>
<td>Course G</td>
<td>Course H</td>
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<tr>
<td>Year 3</td>
<td>Course I</td>
<td>Course J</td>
<td>Course K</td>
<td>Course L</td>
</tr>
<tr>
<td>Year 4</td>
<td>Course M</td>
<td>Course N</td>
<td>Course O</td>
<td>Course P</td>
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<tr>
<td>Year 5</td>
<td>Course Q</td>
<td>Course R</td>
<td>Course S</td>
<td>Course T</td>
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<th>Oral communication</th>
<th>Teamwork</th>
<th>Project planning</th>
<th>Written communication</th>
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(Schematic)
Communication in engineering means being able to

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

The skill is embedded in the technical context.
The same contextualised interpretation should be made for teamwork, problem solving, professional ethics, and other engineering skills.

”It’s about educating engineers who can actually engineer!”
IMPLICATIONS - ENGINEERING SKILLS

- 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, and 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.
**INTEGRATED LEARNING - SO WHO SHOULD TEACH?**

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<th><strong>Engineering faculty</strong></th>
<th><strong>Skills experts</strong></th>
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<td>Faculty show their own competence in skill areas and serve as role models</td>
<td>Experts supporting faculty in their own skills development</td>
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<td>Identify the faculty who are most willing and best able to teach skills</td>
<td>Experts coaching faculty in how to support student development of skills</td>
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<td>Faculty must show commitment to engineering skills - they are important and legitimate in education</td>
<td>Experts and faculty collaborate in course development</td>
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<td>The nature of skills depends on the context in which they are taught and assessed - it must be authentic</td>
<td>Experts and faculty teaching together</td>
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<td>Students working knowledge of technical content is reinforced through the practise of engineering skills - they need support and feedback in both</td>
<td>Experts giving students individual support</td>
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<td>Experts and faculty giving feedback together</td>
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**Engineering faculty**

- Faculty show their own competence in skill areas and serve as role models.
- Identify the faculty who are most willing and best able to teach skills.
- Faculty must show commitment to engineering skills - they are important and legitimate in education.
- The nature of skills depends on the context in which they are taught and assessed - it must be authentic.
- Students working knowledge of technical content is reinforced through the practise of engineering skills - they need support and feedback in both.

**Skills experts**

- Experts supporting faculty in their own skills development.
- Experts coaching faculty in how to support student development of skills.
- Experts and faculty collaborate in course development.
- Experts and faculty teaching together.
- Experts giving students individual support.
- Experts and faculty giving feedback together.
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

- Disciplinary courses or modules make explicit connections among related and supporting content and learning outcomes
- Explicit plan identifies ways in which the integration of engineering skills and multidisciplinary connections are to be made

(See Handbook, p. 6)
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

- Curriculum design and learning outcomes can be realized only if the teaching and learning experiences make dual use of student learning time

- Faculty serve as role models in teaching product, process, and system building skills as the same time as engineering principles and theory

(See Handbook, p. 10)
The CDIO curriculum design process
Starting point I: Validation

What learning outcomes should be prioritized in this program?

Validate plans with your stakeholders
- alumni
- students
- industry
- accreditation bodies
- government/society
- faculty
- ...

...
[Benchmarking Engineering Curricula with the CDIO Syllabus. Bankel et al. (2005) 
Starting point II: Existing curriculum

- Benchmark the existing curriculum for the inclusion of CDIO learning outcomes and topics
- Benchmark existing teaching, learning, and assessment practices
- Benchmark the availability and use of existing workspaces and facilities
METHODS

• Interviews
• Focus groups
• Written questionnaires or surveys
• Comparative studies with peer institutions
• Examination of “best practice” programs
• Reviews of published data
SAMPLE #1

**FOCUS:** Benchmarking the inclusion of CDIO learning outcomes in the curriculum

**METHOD:** Structured interviews and surveys

** RESPONDENTS:** Faculty and academic staff

**KEY QUESTIONS:** To what extent are each of the CDIO learning outcomes included in your course? Do you introduce them? Do you explicitly teach them? Do you assume students have already learned them, and proceed to apply (utilize) them?

(See Handbook, pp. 23-24)

SAMPLE #2

**FOCUS:** Benchmarking the teaching and learning of CDIO learning outcomes at the course or module level

**METHOD:** Open-ended interviews

**RESPONDENTS:** Faculty and academic staff

**KEY QUESTIONS:** What learning outcomes from the CDIO Syllabus do you address? What do you expect students to have learned prior to your course? How do students get feedback on their learning, and how do they use that feedback?

(See Handbook, p. 25)
CURRICULUM STRUCTURE

1. Change the course structure?

2. Retask existing courses?

3. Create new courses?
SAMPLE STRUCTURES

Conventional

Sequential

Block

Bus or Backbone

Linked/merged

Simultaneous

Time
(Based on the curriculum in the Aeronautics and Astronautics program at MIT)

## 3.2 Communications

<table>
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<th>SEQUENCE</th>
<th>MAPPING</th>
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<tr>
<td>Write short individual structured reports. Create sketches, charts and simple graphics. Practice simple interpersonal communications.</td>
<td>Unified Engineering (16.01 - 16.04)</td>
</tr>
<tr>
<td>Write and present individual or small team short reports, such as lab reports.</td>
<td>Thermal Energy (16.05) Controls (16.06) Dynamics (16.08)</td>
</tr>
<tr>
<td>Create and use discipline-specific graphical communications.</td>
<td>Professional Area Subjects (PAS)</td>
</tr>
<tr>
<td>Write large, collaborative reports of a briefing nature. Present collaborative oral report of conference quality. Use appropriate research resources. Implement appropriate communication strategy based on audience and genre.</td>
<td>Capstone Courses (16.82) (16.83)</td>
</tr>
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</table>
SEQUENCING 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 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
Table of contents

Introduction
Program goals
Engineering skills (CDIO Syllabus to second level of detail and associated expected proficiencies)

Program structure
Program plan
Explicit disciplinary links between courses
Program design matrix
Sequences for selected engineering skills

All courses in program
Intended learning outcomes
Contribution to engineering skills

(See Handbook, pp. 27-28)
Course development phase

1. Create new courses or retask existing ones
   – build on existing strengths (consolidate & develop existing learning activities)
   – work with faculty who are willing & able
   – invite proposals rather than give orders

2. Supporting the development
   – allocate resources for course development, give individual support
   – allocate resources for faculty development: individual support, workshops etc

Remember that we are developing the people as much as we are developing the programme
Introduce (I)
Expose the students to a topic. No explicit learning objectives. No major activities such as assignments, exercises or projects. No assessment is linked to this topic.

Teach (T)
There is an explicit learning objective. Compulsory activities, such as assignments, exercises or projects are specifically linked to this topic. Students are assessed and receive feedback, it may or may not affect grade.

Utilize (U)
Assumes students already have some proficiency in this topic. It is utilized mainly to learn and/or assess other learning objectives.
CONSTRUCTIVE ALIGNMENT - A MODEL FOR COURSE DEVELOPMENT

Formulating objectives

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

Designing activities

What work should the students do, to reach the objectives?

Designing assessment

What should the students do, to demonstrate that they reached the objectives?

Constructive alignment, Biggs 1999
Process overview

1a. Validation with stakeholders

1b. Benchmarking existing courses

2. Mapping of CDIO competences to existing and new courses

3. Course development

4. Fine-tune coordination
To what extent does your program have clearly documented evidence of where students are taught engineering skills?