THE CDIO APPROACH TO ENGINEERING EDUCATION: Introduction

Revised January 2008

© CDIO, 2008
WORKSHOP OBJECTIVES

- Explain the CDIO approach to engineering education
- Determine ways in which the CDIO approach may be adapted to your own programs
- Share your ideas and experiences of engineering education reform
PLAN FOR TODAY’S WORKSHOP

INTRODUCTION

WHY
CDIO AS THE CONTEXT
THE CDIO SYLLABUS

WHAT
DESIGN-IMPLEMENT EXPERIENCES
WORKSPACES

HOW
INTEGRATED CURRICULUM
LEARNING
ASSESSMENT
FACULTY COMPETENCE

HOW WELL
PROGRAM EVALUATION

IMPLEMENTATION

WHY
INTRO TO ENGINEERING

PLAN FOR TODAY'S WORKSHOP
<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 - 8:15</td>
<td>Introductions</td>
</tr>
<tr>
<td>8:15 - 9:45</td>
<td>1. Establishing the Context and Defining the Learning Outcomes</td>
</tr>
<tr>
<td>9:45 - 10:00</td>
<td>BREAK</td>
</tr>
<tr>
<td>10:00 - 11:15</td>
<td>2. Designing an Integrated Curriculum</td>
</tr>
<tr>
<td>11:15 - 12:15</td>
<td>3. Engaging Students in Their Learning</td>
</tr>
<tr>
<td>12:15 - 13:15</td>
<td>LUNCH</td>
</tr>
<tr>
<td>13:15 - 14:30</td>
<td>4. Designing and Integrating Design-Implement Experiences</td>
</tr>
<tr>
<td>14:30 - 15:45</td>
<td>5. Assessing Student Learning</td>
</tr>
<tr>
<td>15:45 - 16:00</td>
<td>BREAK</td>
</tr>
<tr>
<td>16:00 - 17:00</td>
<td>6. Adapting and Implementing the CDIO Approach</td>
</tr>
</tbody>
</table>
Please print your information on an index card:

- Name
- University
- Department or Program
- Email address
- Principal role in the program, e.g., department head, faculty, instructional support staff
- Reason(s) you are participating in this workshop
THE CDIO APPROACH TO ENGINEERING EDUCATION:
1. Establishing the Context and Defining the Learning Outcomes
SESSION ONE OBJECTIVES

- Explain the CDIO approach to engineering education
- Describe the content and structure of the CDIO Syllabus
- Learn how to engage stakeholders in the validation of program objectives
CENTRAL QUESTIONS FOR ENGINEERING EDUCATION

**WHAT** knowledge, skills and attitudes should students possess as they graduate from university?

**HOW** can we do better at ensuring that students learn these skills?
THE UNDERLYING NEED FOR REFORM

Desired Attributes of an Engineering Graduate

- Understanding of fundamentals
- Understanding of design and manufacturing process
- A multidisciplinary system perspective
- Good communication skills
- High ethical standards, etc.

THE MESSAGE

The Underlying Need

Educate students who:

- Understand how to conceive-design-implement-operate
- Complex value-added engineering systems
- In modern team-based engineering environments

We have adopted CDIO as the engineering CONTEXT of our education
Personal and Interpersonal Skills, and Product, Process, and System Building Skills

Pre-1950s: Practice

1960s: Science & practice

1980s: Science

2000: CDIO

Disciplinary Knowledge

Engineers need both dimensions, and we need to develop education that delivers both
To educate students who are able to:

• Master a deeper working knowledge of the technical fundamentals

• Lead in the creation and operation of new products, processes, and systems

• Understand the importance and strategic impact of research and technological development on society
VISION

We envision an education that stresses the fundamentals, set in the context of **Conceiving – Designing – Implementing – Operating** products, processes, and systems

- A curriculum organized around mutually supporting disciplinary courses, with C-D-I-O activities highly interwoven
- Design-implement experiences set in both classrooms and modern learning workspaces
- Active and experiential learning incorporated into disciplinary courses
- Comprehensive assessment and evaluation processes
• Most engineers tend to learn from the concrete to the abstract, e.g., in manipulating objects to understand theoretical concepts

• Many students arrive at university lacking personal experience in building or repairing objects

• Design-implement activities and other forms of experiential learning build the cognitive framework students need to understand the fundamentals more deeply

• In a CDIO approach, learning activities have a dual impact of deepening technical knowledge while developing product, process, and system building skills
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

- It’s what engineers do!
- Provides the framework for teaching skills
- Allows deeper learning of the fundamentals
- Helps to attract, motivate, and retain students

*(See Handbook, p. 4)*
ACTIVITY: SMALL-GROUP DISCUSSION

In what ways are you improving engineering education in your own programs?

What are the major barriers to reform in your programs?

Do you think these barriers are common around the world or unique to your program?
UNDERLYING NEED TO GOALS

Educate students who:

• Understand how to conceive-design-implement-operate
• Complex value-added engineering systems
• In a modern team-based engineering environment
• And are mature and thoughtful individuals

The CDIO Syllabus - a comprehensive statement of detailed goals for an engineering education
1.0 Technical Knowledge & Reasoning
  Knowledge of underlying sciences
  Core engineering fundamental knowledge
  Advanced engineering fundamental knowledge

2.0 Personal and Professional Skills & Attributes
  Engineering reasoning and problem solving
  Experimentation and knowledge discovery
  System thinking
  Personal skills and attributes
  Professional skills and attributes

3.0 Interpersonal Skills: Teamwork & Communication
  Multi-disciplinary teamwork
  Communications
  Communication in a foreign language

4.0 Conceiving, Designing, Implementing & Operating Systems in the
Enterprise & Societal Context
  External and societal context
  Enterprise and business context
  Conceiving and engineering systems
  Designing
  Implementing
  Operating
CDIO SYLLABUS

• Syllabus at 3rd level of detail
• One or two more levels are detailed
• Rational
• Comprehensive
• Peer reviewed
• Basis for design and assessment

(See Handbook, p. 17)
Stakeholders are individuals or groups who share an interest, and have an investment, in graduates of a particular program. They benefit from the program’s success, and hold programs accountable for results.

Who are the stakeholders of your programs?

Methods to get stakeholder input and support:
- Interviews
- Focus-group discussions
- Surveys
- Peer review
- Workshops
**Sample:** 6 groups surveyed: 1st- and 4th-year students, alumni 25 years old, alumni 35 years old, faculty, leaders of industry

**Question:** For each attribute, please indicate which of the five levels of proficiency you desire in a graduating engineering student:

**Scale:**

1. To have experienced or been exposed to
2. To be able to participate in and contribute to
3. To be able to understand and explain
4. To be skilled in the practice or implementation of
5. To be able to lead or innovate in
Massachusetts Institute of Technology, Cambridge

REMARKABLE AGREEMENT!

SAMPLE SURVEY RESULTS
2.1 Eng. Reasoning and Problem Solving
2.2 Experimenting and Knowledge Discovery
2.3 System Thinking
2.4 Personal Skills
2.5 Professional Skills & Attitudes
3.1 Teamwork and Leadership
3.2 Communications
4.1 External & Societal Context
4.2 Enterprise & Business Context
4.3 Conceiving
4.4 Designing
4.5 Implementing
4.6 Operating

Massachusetts Institute of Technology
Queen’s University Belfast
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

- Allows for the design of curriculum
- Serves as the basis of student learning assessment

(See Handbook, p. 5)
Rate your own proficiency of each CDIO learning outcome at the x.x level.

Use:

- the condensed version of the *CDIO Syllabus*, found in the Handbook
- the five levels of proficiency:
  1. To have experienced or been exposed to
  2. To be able to participate in and contribute to
  3. To be able to understand and explain
  4. To be skilled in the practice or implementation of
  5. To be able to lead or innovate in
**How can we do better?**

**Retask** current assets and resources in:

- Curriculum
- Teaching and learning methods
- Design-implement experiences and engineering workspaces
- Learning assessment methods
- Faculty competence
- Program evaluation

Evolve to a model in which these resources are better employed to **promote student learning**
# BEST PRACTICE: THE CDIO STANDARDS

<table>
<thead>
<tr>
<th>1. The Context</th>
<th>7. Integrated Learning Experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption of the principle that product, Process, and system lifecycle development and deployment are the context for engineering education</td>
<td>Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal, interpersonal, and product, process, and system building skills</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Learning Outcomes</th>
<th>8. Active Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific, detailed learning outcomes for personal, interpersonal, and product, process, and system building skills, consistent with program goals and validated by program stakeholders</td>
<td>Teaching and learning based on active experiential learning methods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Integrated Curriculum</th>
<th>9. Enhancement of Faculty Skills Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>A curriculum designed with mutually supporting disciplinary subjects, with an explicit plan to integrate personal, interpersonal, and product, process, and system building skills</td>
<td>Actions that enhance faculty competence in personal, interpersonal, and product and system building skills</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Introduction to Engineering</th>
<th>10. Enhancement of Faculty Teaching Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>An introductory course that provides the framework for engineering practice in product, Process, and system building, and introduces essential personal and interpersonal skills</td>
<td>Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Design-Implement Experiences</th>
<th>11. Learning Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A curriculum that includes two or more design-implment experiences, including one at a basic level and one at an advanced level</td>
<td>Assessment of student learning in personal, interpersonal, and product, process, and system building skills, as well as in disciplinary knowledge</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Workspaces and laboratories that support and encourage hands-on learning of product, process, and system building, disciplinary knowledge, and social learning</td>
<td>A system that evaluates programs against these 12 standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement</td>
</tr>
</tbody>
</table>
1. How would you explain the goals and vision of the CDIO approach to engineering education to a colleague who is not here today?

2. To what extent can the content and structure of the CDIO Syllabus be adapted to your program?

3. What are the best ways of engaging your program’s stakeholders in determining appropriate objectives and outcomes?