CONCEIVE DESIGN IMPLEMENT OPERATE

THE CDIO APPROACH TO ENGINEERING EDUCATION: Introduction

Revised September 2009

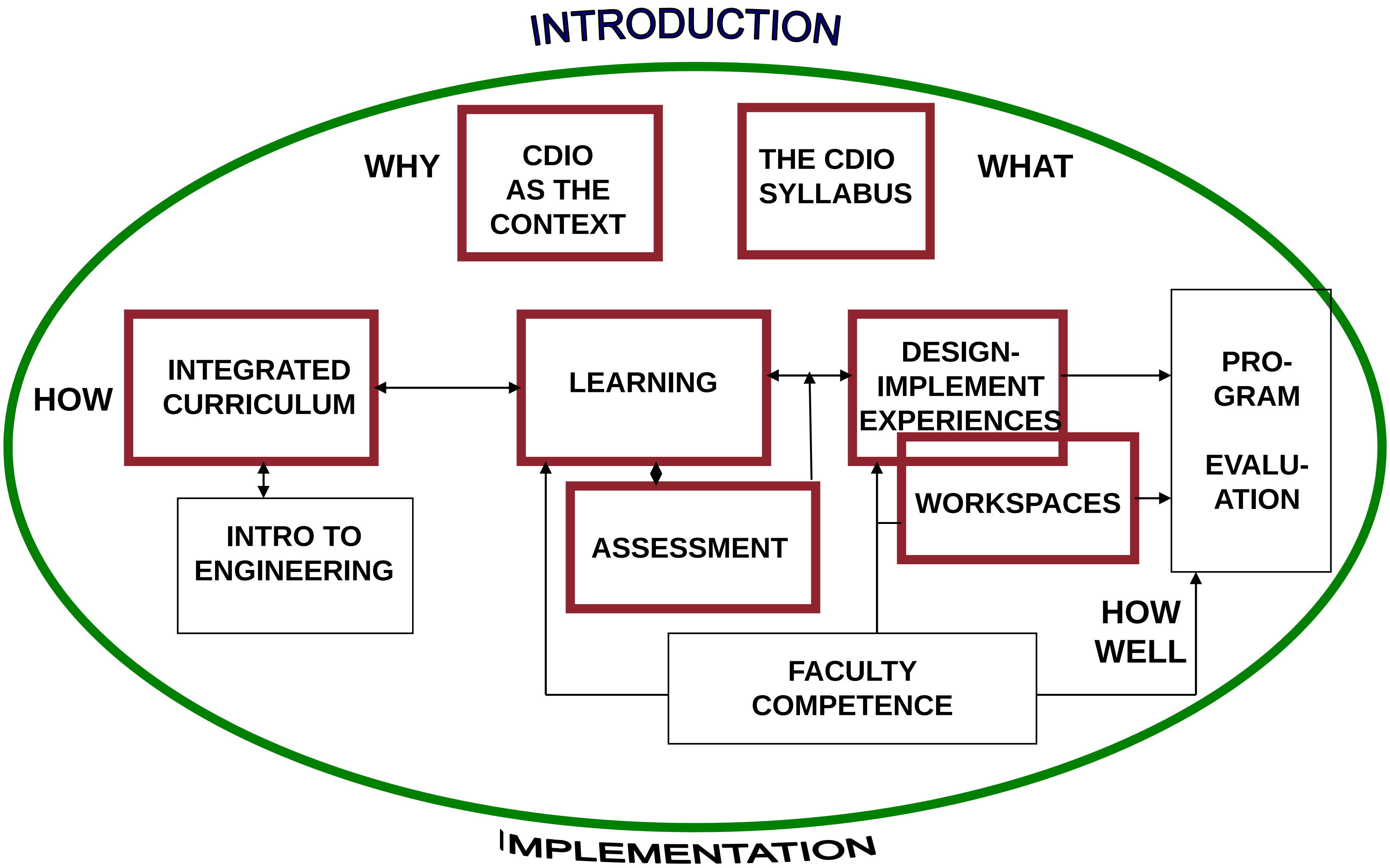
WORKSHOP OBJECTIVES

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



SCHEDULE

8:00 - 8:15 8:15 - 9:45	Introductions 1. Establishing the Context and Defining the Learning Outcomes
9:45 - 10:00	BREAK
10:00 - 11:15	2. Designing an Integrated Curriculum
11:15 - 12:15	3. Engaging Students in Their Learning
12:15 - 13:15	LUNCH
13:15 - 14:30	4. Designing and Integrating Design-Implement Experiences
14:30 - 15:45	5. Assessing Student Learning
15:45 - 16:00	BREAK
16:00 - 17:00	6. Adapting and Implementing the CDIO Approach

INTRODUCTIONS

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**

CDIO
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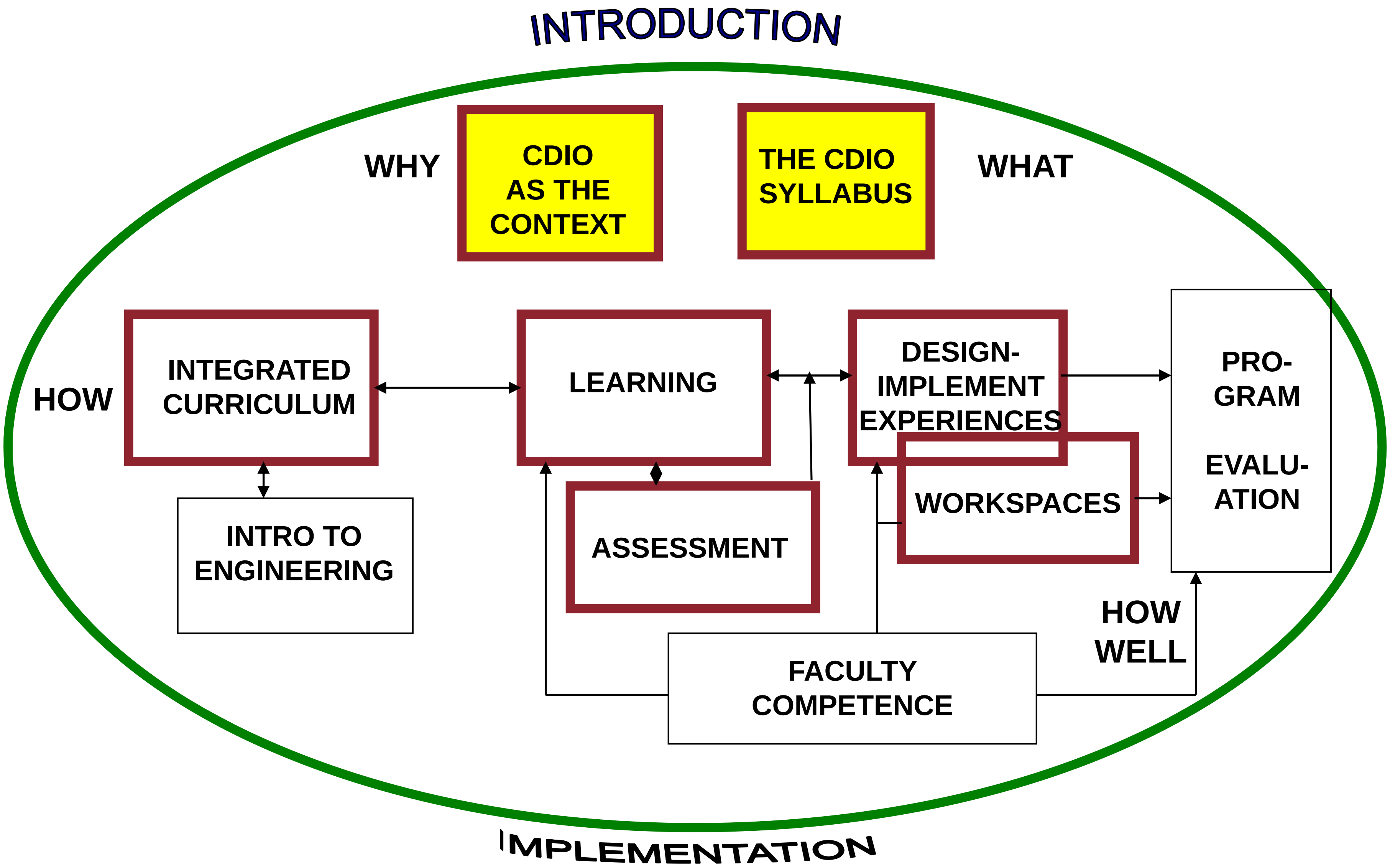
THE CDIO APPROACH TO ENGINEERING EDUCATION: 1. Establishing the Context and Defining the Learning Outcomes

WORKSHOP SESSION ONE



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

cdio

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

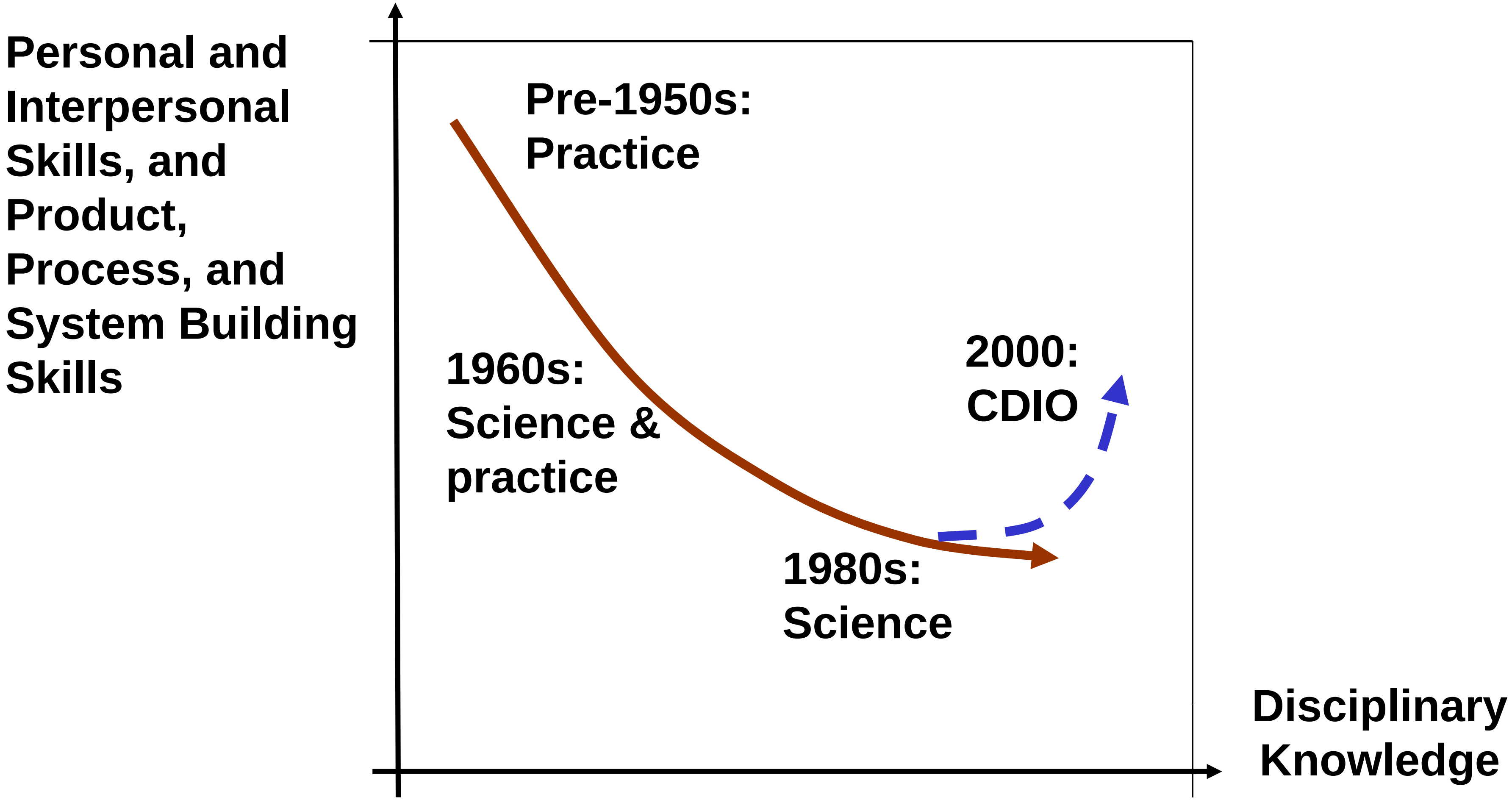
The Underlying Need

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 <u>CONTEXT</u> of our education

NOTIONAL DEVELOPMENT OF ENGINEERING EDUCATION



Engineers need *both* dimensions, and we need to develop education that delivers both

GOALS OF CDIO

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**

RATIONALE FOR A CDIO APPROACH

- **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**

BEST PRACTICE

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?

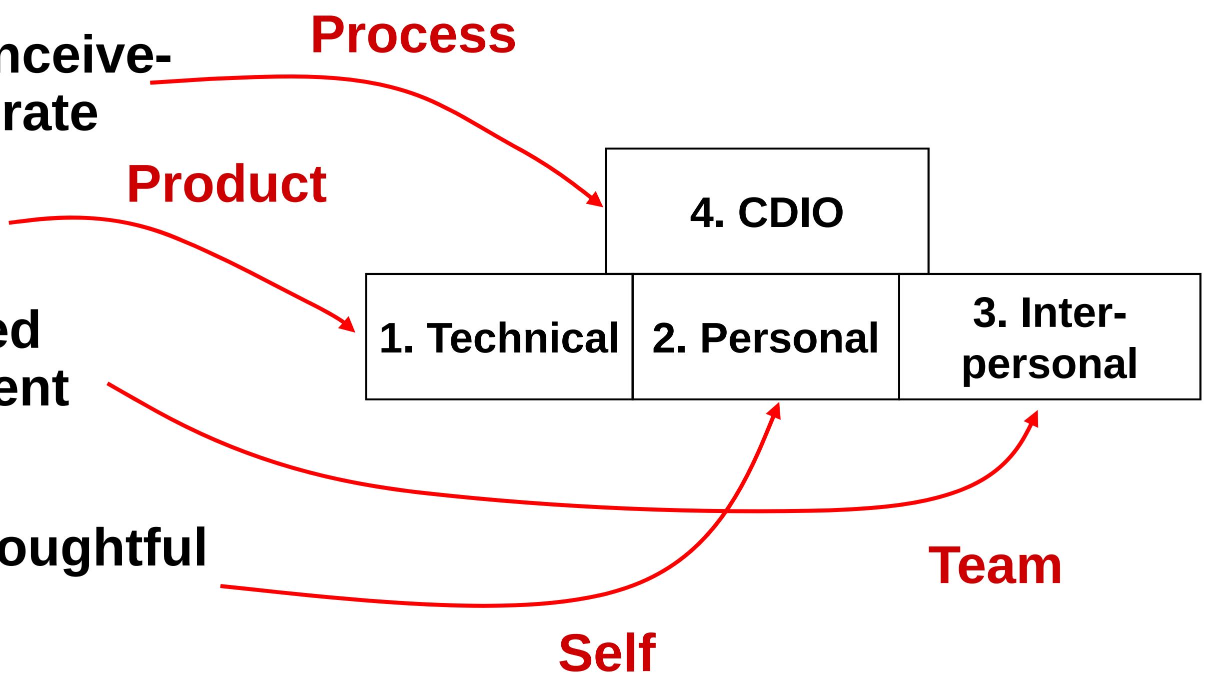
What are the major barriers to reform in your programs?

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 <u>goals for an engineering education</u>

THE CDIO SYLLABUS

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**

SCIENCES
1.2. CORE ENGINEERING FUNDAMENTAL KNOWLEDGE
1.3. ADVANCED ENGINEERING FUNDAMENTAL KNOWLEDGE

2 PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES
2.1. ENGINEERING REASONING AND PROBLEM SOLVING
2.1.1. Problem Identification and Formulation
2.1.2. Modeling
2.1.3. Estimation and Qualitative Analysis
2.1.4. Analysis With Uncertainty
2.1.5. Solution and Recommendation
2.2. EXPERIMENTATION AND KNOWLEDGE DISCOVERY
2.2.1. Hypothesis Formulation
2.2.2. Survey of Print and Electronic Literature
2.2.3. Experimental Inquiry
2.2.4. Hypothesis Test, and Defense
2.3. SYSTEM THINKING
2.3.1. Thinking Holistically
2.3.2. Emergence and Interactions in Systems
2.3.3. Prioritization and Focus
2.3.4. Tradeoffs, Judgment and Balance in Resolution
2.4. PERSONAL SKILLS AND ATTITUDES
2.4.1. Initiative and Willingness to Take Risks
2.4.2. Perseverance and Flexibility
2.4.3. Creative Thinking
2.4.4. Critical Thinking
2.4.5. Awareness of OneÕs Personal Knowledge, Skills, and Attitudes
2.4.6. Curiosity and Lifelong Learning
2.4.7. Time and Resource Management
2.5. PROFESSIONAL SKILLS AND ATTITUDES
2.5.1. Professional Ethics, Integrity, Responsibility and Accountability
2.5.2. Professional Behavior
2.5.3. Proactively Planning for OneÕs Career
2.5.4. Staying Current on World of Engineer

3 INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION
3.1. TEAMWORK
3.1.1. Forming Effective Teams
3.1.2. Team Operation
3.1.3. Team Growth and Evolution
3.1.4. Leadership
3.1.5. Technical Teaming
3.2. COMMUNICATION
3.2.1. Communication Strategy
3.2.2. Communication Structure
3.2.3. Written Communication
3.2.4. Electronic/Multimedia Communication
3.2.5. Graphical Communication
3.2.6. Oral Presentation and Interpersonal Communication
3.3.1. English
3.3.2. Languages within the European Union
3.3.3. Languages outside the European Union

4 CONCEIVING, DESIGNING, IMPLEMENTING AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT
4.1. EXTERNAL AND SOCIETAL CONTEXT
4.1.1. Roles and Responsibility of Engineers
4.1.2. The Impact of Engineering on Society
4.1.3. SocietyÕs Regulation of Engineering
4.1.4. The Historical and Cultural Context
4.1.5. Contemporary Issues and Values
4.1.6. Developing a Global Perspective
4.2. ENTERPRISE AND BUSINESS CONTEXT
4.2.1. Appreciating Different Enterprise Cultures
4.2.2. Enterprise Strategy, Goals and Planning
4.2.3. Technical Entrepreneurship
4.2.4. Working Successfully in Organizations
4.3. CONCEIVING AND ENGINEERING SYSTEMS
4.3.1. Setting System Goals and Requirements
4.3.2. Defining Function, Concept and Architecture
4.3.3. Modeling of System and Ensuring Goals Can Be Met
4.3.4. Development Project Management
4.4. DESIGNING
4.4.1. The Design Process
4.4.2. The Design Process Phasing and Approaches
4.4.3. Utilization of Knowledge in Design
4.4.4. Disciplinary Design
4.4.5. Multidisciplinary Design
4.4.6. Multi-objective Design
4.5. IMPLEMENTING
4.5.1. Designing the Implementation Process
4.5.2. Hardware Manufacturing Process
4.5.3. Software Implementing Process
4.5.4. Hardware Software Integration
4.5.5. Test, Verification, Validation and Certification
4.5.6. Implementation Management
4.6. OPERATING
4.6.1. Designing and Optimizing Operations
4.6.2. Training and Operations
4.6.3. Supporting the System Lifecycle
4.6.4. System Improvement and Evolution
4.6.5. Disposal and Life-End Issues
4.6.6. Operations Management

(See Handbook, p. 17)

VALIDATION WITH KEY STAKEHOLDERS

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 STAKEHOLDER SURVEY AT MIT

***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 <u>exposed</u> to

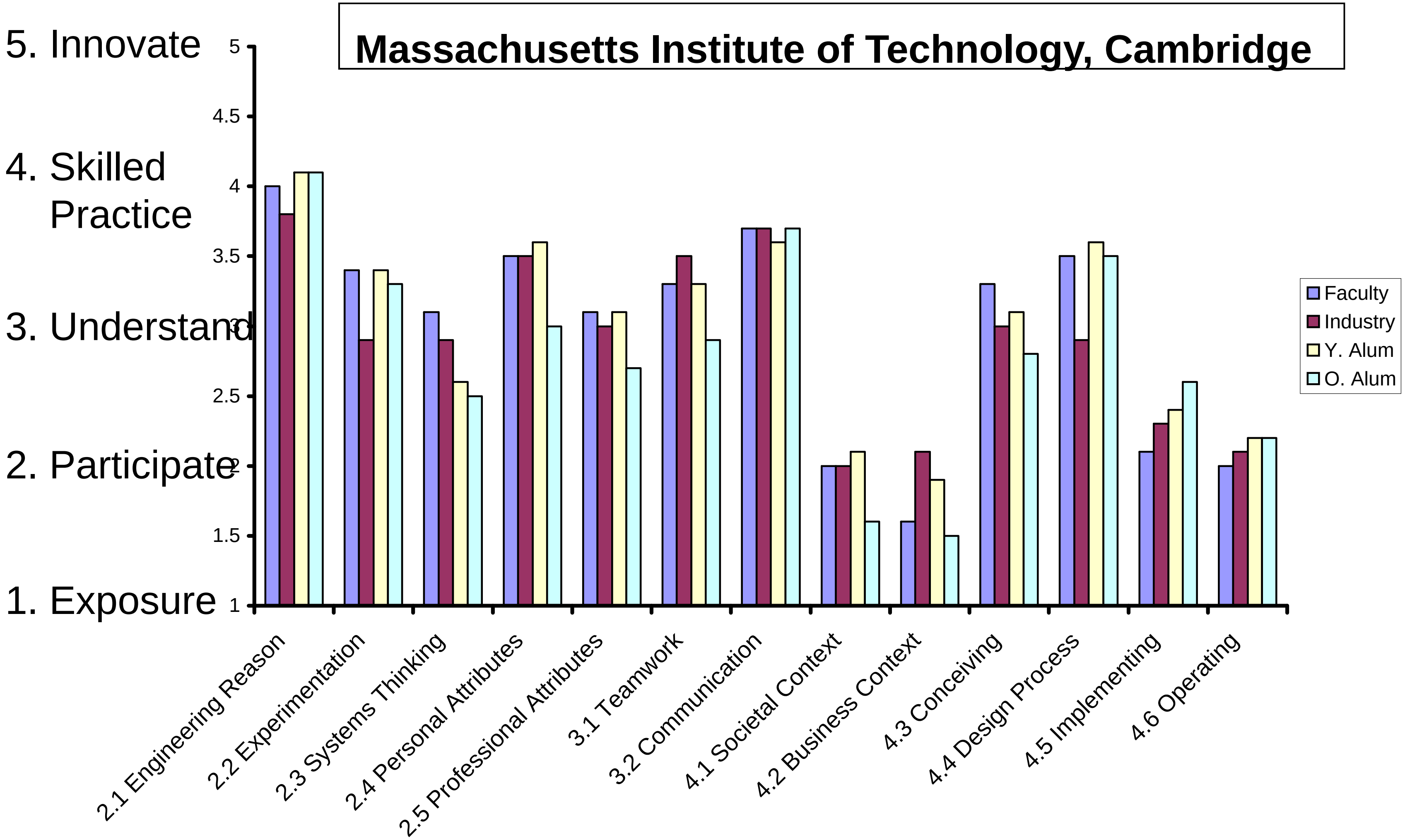
2 To be able to <u>participate</u> in and contribute to

3 To be able to <u>understand</u> and explain

4 To be <u>skilled in the practice</u> or implementation of

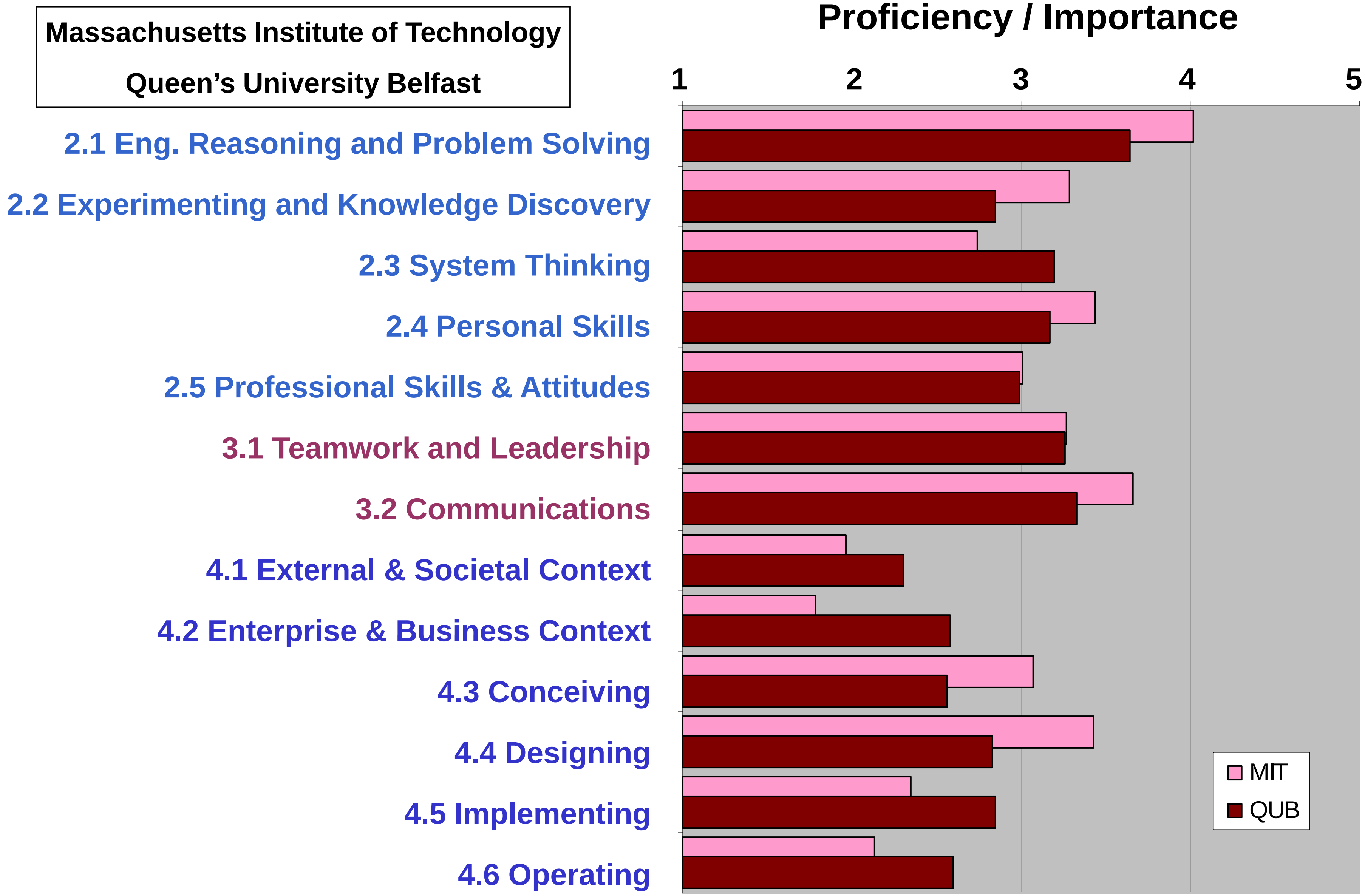
5 To be able to lead or <u>innovate</u> in

SAMPLE SURVEY RESULTS



REMARKABLE AGREEMENT!

SAMPLE SURVEY RESULTS - ALUMNI



BEST PRACTICE

CDIO Standard 2 -- Learning Outcomes

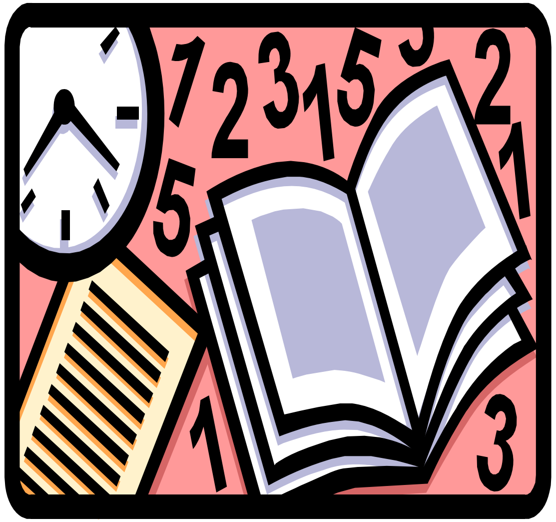
Specific, detailed learning outcomes for personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge, consistent with program goals and validated by program stakeholders

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

(See Handbook, p. 5)

ACTIVITY: EXPECTED PROFICIENCY

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

1. The Context
Adoption of the principle that product. Process, and system lifecycle development and deployment are the context for engineering education

2. Learning Outcomes
Specific, detailed learning outcomes for personal, interpersonal, and product,.process and system building skills, consistent with program goals and validated by program stakeholders

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

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

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

6. Engineering Workspaces
Workspaces and laboratories that support and encourage hands-on learning of product, process, and system building, disciplinary knowledge, and social learning

7. Integrated Learning Experiences
Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal, interpersonal, and produc, process,t and system building skills

8. Active Learning
Teaching and learning based on active experiential learning methods

9. Enhancement of Faculty Skills Competence
Actions that enhance faculty competence in personal, interpersonal, and product and system building skills

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

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

12. Program Evaluation
A system that evaluates programs against these 12 standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement

REFLECTION AND SHARING

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?