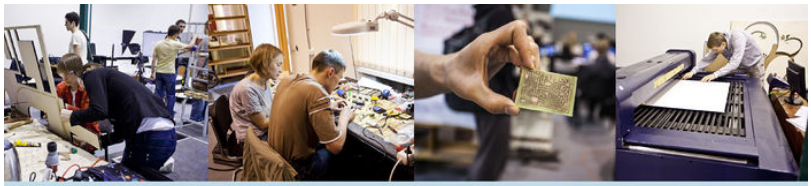


Conceive| Design| Implement| Operate

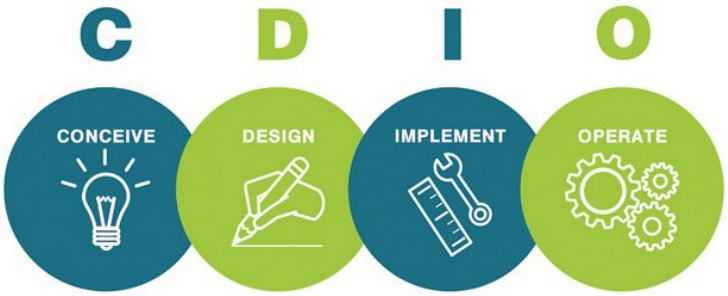
CDIO

DR. DAYANA FARZEEHA ALI
DR. NORASYKIN BINTI MOHD ZAID

Session Objectives

- Explain the CDIO Engineering Education Framework
- Share experiences of engineering education reform
- Identify ways in which the CDIO approach may be useful to your programs

WHAT IS CDIO?



CDIO is an educational framework stressing engineering fundamentals set in the context of Conceive – Design - Implementation – Operation real world product and system.

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Overview of CDIO Engineering Education Framework

The key components and activities in the CDIO Framework are based on two key documents

CDIO Syllabus (the 'what' of CDIO)
CDIO Standards (the 'how' of CDIO)

4

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The CDIO Generic Syllabus

1. **Technical Knowledge & Reasoning**:
   - Knowledge of underlying sciences
   - Core engineering fundamental knowledge
   - Advanced engineering fundamental knowledge
2. **Personal and Professional Skills & Attributes**
   - 2.1 Engineering reasoning and problem solving
   - 2.2 Experimentation and knowledge discovery
   - 2.3 System thinking
   - 2.4 Personal skills and attributes
   - 2.5 Professional skills and attributes
3. **Interpersonal Skills: Teamwork & Communication**
   - 3.1 Teamwork
   - **3.2 Communications**
4. **Conceiving, Designing, Implementing & Operating Systems in the Enterprise & Societal Context**
   - 4.1 External and societal context
   - 4.2 Enterprise and business context
   - 4.3 Conceiving
   - 4.4 Designing
   - 4.5 Implementing
   - 4.6 Operating
   - 4.7 Leading Engineering Endeavours
   - 4.8 Entrepreneurship

NEW

CDIO Standards

	Standard 1	Adopt CDIO as a context
Curriculum	Standard 2	CDIO Syllabus Outcomes
	Standard 3	Integrated Curriculum
	Standard 4	Introduction to Engineering
	Standard 5	Design-Build Experiences
Workspace/Labs	Standard 6	CDIO Workspaces
Teaching & Learning Methods	Standard 7	Integrated Learning Experiences
	Standard 8	Active Learning
Enhancement of Faculty Competence	Standard 9	Enhancement of Staff CDIO Skills
	Standard 10	Enhancement of Staff Teaching Skills
Assessment Methods	Standard 11	CDIO Skills Assessment
	Standard 12	CDIO Program Evaluation

The 12 CDIO Standards: SP Context

1. CDIO as Context
Adoption of the principle that product and system lifecycle development and deployment are the context for engineering education

2. CDIO Syllabus Outcomes
Specific, detailed learning outcomes for personal, interpersonal, and product 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 and system building skills

4. Introduction to Engineering
An introductory course that provides the framework for engineering practice in product 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 and system building, disciplinary knowledge, and social learning

Course Doc (Course Aims)

Module Syllabus GLO / SLO

Course Structure, Modules

Year 1 Module

Projects: Mini, Major

Facilities & Equipment

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The 12 CDIO Standards – cont'd

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

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

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

10. Enhancement of Faculty Teaching Skills
Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning

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

12. CDIO 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

Student-centered Learning

Staff Competency, Training (SDP)

(Integrated) Assessment

Quality Assurance

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Standard 1 - CDIO as 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

Description: CDIO is considered the *context* for engineering education in that it is the cultural framework, or environment, in which technical knowledge and other skills are taught, practiced and learned. The principle is *adopted* by a program when there is explicit agreement of faculty to initiate CDIO, a plan to transition to a CDIO program, and support from program leaders to sustain reform initiatives.

Its what Engineers do

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Standard 2 - Learning Outcomes

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

Description: The knowledge, skills, and attitudes intended as a result of engineering education, *i.e.,* the *learning outcomes*, are codified in the *CDIO Syllabus*. These learning outcomes, also called learning objectives, detail what students should know and be able to do at the conclusion of their engineering programs. In addition to learning outcomes for technical disciplinary knowledge, the *CDIO Syllabus* specifies learning outcomes as personal, interpersonal, and product and system building (i.e. Conceive-Design-Implement-Operate).

Learning outcomes are reviewed and validated by key *stakeholders*, groups who share an interest in the graduates of engineering programs, for consistency with *program goals* and relevance to engineering practice. In addition, stakeholders help to determine the expected level of proficiency, or standard of achievement, for each learning outcome.

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CDIO Skills:

SP-customized CDIO Syllabus

CDIO Syllabus: Customized for SP (sample)

MIT-CDIO syllabus

System Thinking

1. Thinking Holistically
2. Emergence and Interactions in Systems
3. Prioritization and Focus
4. Trade-offs, Judgement and Balance in Resolution

Professional Skills and Attitudes

1. Professional Ethics, Integrity, Responsibility & Accountability
2. Professional Behaviour
3. Proactively Planning for One's Career
4. Staying Current on World of Engineer

SP-CDIO syllabus

System Thinking

1.Understand the Basis and Methods for System Thinking
2.Analyse the Workings of Systems
3.Use a Range of Relevant System Thinking Tools

Professional Skills and Attitudes

1. Evaluate the Impact of Values and Ethics
2. Demonstrate Professional Behaviour at Work and in Society
3. Stay Current on Emerging Research and Practices in your Field

The CDIO Generic Syllabus

Contains 2-3 more layers of detail

1. **Technical Knowledge & Reasoning**:
   - Knowledge of underlying sciences
   - Core engineering fundamental knowledge
   - Advanced engineering fundamental knowledge
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   - 4.6 Operating
   - 4.7 Leading Engineering Endeavours
   - 4.8 Entrepreneurship NEW

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Levels of CDIO Syllabus
(Learning Outcomes)

3. Interpersonal Skills: Teamwork & Communication

3.2 **COMMUNICATIONS**

3.2.1 Design appropriate communications strategies

Level X.X

Level X.X.X

Level XXXX Customized to SP context

Analyze the communication situation e.g., in terms of purpose, audience and context (PAC)
Identify key considerations in communicating across cultures and disciplines
Identify communications objectives
Read critically and select relevant content
Identify and choose appropriate communication structure and style
Select appropriate multimedia and graphical communication (e.g. email, voicemail, video conferencing, tables and charts, sketching and drawing)

3.2.2 Demonstrate effective written communication

3.2.3 Demonstrate effective oral communication

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Underpinning Knowledge

For any specific learning objective: whether this is knowledge, skill, or attitudinally based – there will be essential knowledge that *underpins* understanding and/or competence

In basic terms this is the "*stuff* " that a teacher needs to *know* in order to be able to teach the objective

…….. Sample Underpinning Knowledge

3.2 **COMMUNICATIONS**

3.2.1 Design appropriate communications strategies

- *Analyze the communication situation e.g., in terms of purpose, audience and context (PAC)*
- *Identify key considerations in communicating across cultures and disciplines*
- *Identify* communications objectives
- *Read critically and select relevant content*
- *Identify and choose appropriate communication structure and style*
- *Select appropriate multimedia and graphical communication (e.g. email, voicemail, video conferencing, tables and charts, sketching and drawing)*

The different purposes that may be intended by a communicator (e.g. Convey facts, influence perception and beliefs, change behaviors, etc). How audiences differ (e.g. Gender, ethnicity, competence, belief systems, etc) and the implications for how communcation is conducted. How context (e.g. what is occurring now, has recently occurred, time and place, who is present – or not present, physical conditions, etc) may significantly influence the perceived meaning of human communication by audiences

THE INSTITUTION OF ENGINEERS SINGAPORE

Engineering Accreditation Board

Accreditation Manual (April 2008)

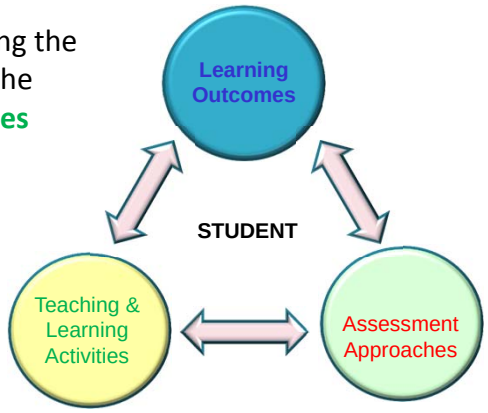
The programme should ensure that graduates are able to:

a) apply knowledge of mathematics, science and engineering;
b) design and conduct experiments, analyse, interpret data and synthesise valid conclusions;
c) design a system, component, or process, and synthesise solutions to achieve desired needs;
d) identify, formulate, research through relevant literature review, and solve engineering problems reaching substantiated conclusions;
e) use the techniques, skills, and modern engineering tools necessary for engineering practice with appropriate considerations for public health and safety, cultural, societal, and environmental constraints;
f) communicate effectively;
g) recognize the need for, and have the ability to engage in life-long learning;
h) understand the impact of engineering solutions in a societal context and to be able to respond effectively to the needs for sustainable development;
i) function effectively within multi-disciplinary teams and understand the fundamental precepts of effective project management;
j) understand professional, ethical and moral responsibility.

Curriculum Alignment

Learning Outcomes
serve as the basis for developing the
Assessment Approaches and the
Teaching and Learning Activities

Often referred to as
"Constructive Alignment"
(Biggs)



Standard 3 - Integrated Curriculum

A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal, inter-personal, and product, process and system building skills

Description: A CDIO curriculum includes learning experiences that lead to the acquisition of *personal, interpersonal, and product and system building skills* (Standard 2), integrated with the learning of disciplinary content. Disciplinary subjects are *mutually supporting* when they make explicit connections among related and supporting content and learning outcomes. An *explicit plan* identifies ways in which the integration of CDIO skills and multidisciplinary connections are to be made, for example, by mapping CDIO learning outcomes to courses and co-curricular activities that make up the curriculum.

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Communication as an integrated competence

As engineers, being able to communicate well, is part of the practice of engineers, as they need to be able to:

- Speak with clarity and confidence
- Explain technical concepts at different levels of complexity to different audiences
- Argue the case for engineering proposals and solutions
- Display good interpersonal communications with a range of stakeholders

The same applies to other CDIO skills, such critical and creative thinking, teamwork, ethical reasoning, etc

Examples in the SP context

Existing modules (courses) were reviewed, reorganised and content areas rationalised and updated

Selected CDIO skills were integrated in modules (some modules were specifically identified as most suitable for selected skill integration)

Integration of CDIO skills across modules through integrated learning experiences

Developing the proficiency of skills, through selected modules, over the course duration

Some modules actually removed and new ones added, resulting in a better sequence for the overall programme structure

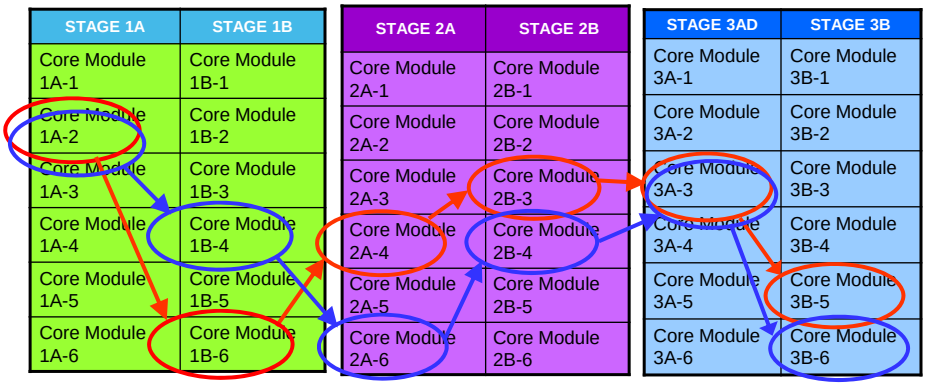
Gap Analysis & Skill Mapping

Each school conducted a gap analysis of their courses. From this, it was possible to:

- Identify where such skills are already present in the curriculum (whether explicitly stated or otherwise)
- Identify where there are naturally occurring opportunities to integrate selected CDIO skills.
- Map and integrate the CDIO skills throughout the course (programme), and in terms of proficiency at module (course) level
- Ensure that the overall structure and sequencing of modules is both effective and efficient in terms of meeting the terminal outcomes of the programme.

Example from Chemical Engineering:

Integration of Communication & Teamwork across 3 years of Study



Year 1: Exposure to CDIO skills

Year 2: Reinforcement of CDIO skills

Year 3: Demonstration of CDIO skills

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Different level of expectations Year 1 to Year 3

→ Example: **Communication**

Year 1: To *appreciate importance* of clear oral communication using walkie-talkie in carrying out the task of ….

Year 1: To *be aware* of Purpose, Audience & Context (PAC) in preparing a memo to different target audience ….

Year 2: To *develop competence* in applying good principles in preparing an oral presentation for ….

Year 3: To *demonstrate competence* in delivering oral presentation to a designated audience in …..

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Standard 4 - Introduction to Engineering

An introductory course that provides the framework for engineering practice in product and system building, and introduces essential personal and interpersonal skills

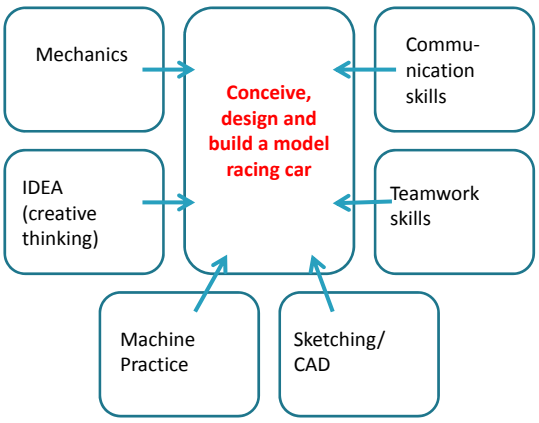
Description: The *introductory* course, usually one of the first required courses in a program, provides a framework for the practice of engineering. This *framework* is a broad outline of the tasks and responsibilities of an engineer, and the use of disciplinary knowledge in executing those tasks. Students engage in the *practice of engineering* through problem solving and simple design exercises, individually and in teams. The course also includes personal and interpersonal knowledge, skills, and attitudes that are *essential* at the start of a program to prepare students for more advanced product and system building experiences.

WHY *Introduction to Engineering*

- "Primacy Effect" (positive first impression) → get student attention, interest and commitment to engineering
- Much of the *criticism* of engineering education by students is that the intrinsically interesting parts of curriculum typically come in later years. Earlier years tend to focus on foundational knowledge → often experienced by students as dry and de-contextualized



Year 1: Introduction to Engineering

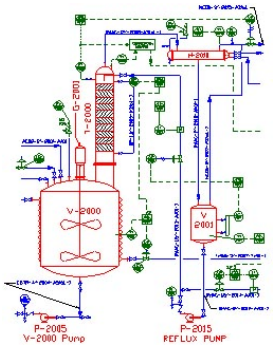


Car Challenge

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

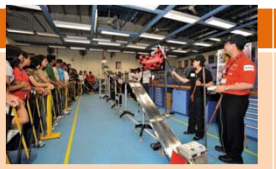
Description: The term *design-implement experience* denotes a range of engineering activities central to the process of developing new products and systems. Included are all of the activities described in Standard One at the *Design* and *Implement* stages, plus appropriate aspects of conceptual design from the *Conceive* stage. Students develop product and system building skills, as well as the ability to apply engineering science, in design-build experiences integrated into the curriculum. Design-build experiences are considered *basic* or *advanced* in terms of their scope, complexity, and sequence in the program.



Design-Implement Experiences

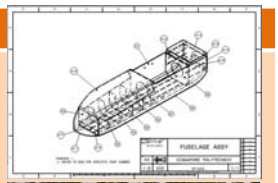
A framework for students to learn engineering by building things

- Provide authentic real world simulated learning experiences → Add realism to the curriculum
- Illustrate connections between engineering disciplines
- Naturally infuses both technical and CDIO skills (e.g. teamwork, communications, thinking, etc.)
- Foster students' creative abilities
- Are motivating for students



Introduction to Engineering
(basic conceive, design and implement)

Year 2 project
Conceive, Design (Design Thinking)



Capstone Project
Conceive, Design, Implement and Operate

Standard 6 – Engineering Workspaces

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

Description: The physical learning environment includes traditional learning spaces, for example, classrooms, lecture halls, and seminar rooms, as well as engineering *workspaces* and *laboratories*. Workspaces and laboratories support the learning of *product and system building skills* concurrently with *disciplinary knowledge*. They emphasize *hands-on learning* in which students are directly engaged in their own learning, and provide opportunities for *social learning*, that is, settings where students can learn from each other and interact with several groups. The creation of new workspaces, or remodeling of existing laboratories, will vary with the size of the program and resources of the institution.

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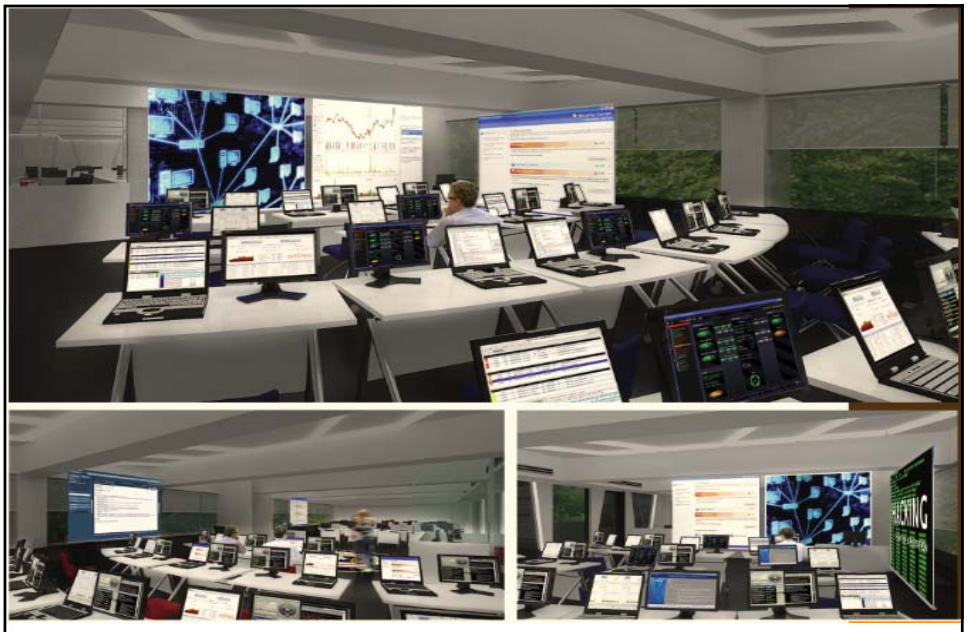

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Standard 7 – Integrated Learning Experiences

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

Description: Integrated learning experiences are pedagogical approaches that foster the learning of disciplinary knowledge simultaneously with personal, interpersonal, and product and system building skills. They incorporate professional engineering issues in contexts where they coexist with disciplinary issues. For example, students might consider the analysis of a product, the design of the product, and the social responsibility of the designer of the product, all in one exercise.

Final Year Project

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Standard 8 – Active Learning

ACTIVE LEARNING

Teaching and learning based on active experiential learning methods

experiential learning
enhancing student engagement & academic success

Description: Active learning methods engage students directly in thinking and problem solving activities. There is less emphasis on passive transmission of information, and more on engaging students in manipulating, applying, analyzing, and evaluating ideas. Active learning in lecture-based courses can include such methods as partner and small-group discussions, demonstrations, debates, concept questions, and feedback from students about what they are learning. Active learning is considered *experiential* when students take on roles that simulate professional engineering practice, for example, design-build projects, simulations, and case studies.

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Learning is not a spectator sport. Students do not learn much just by sitting in class listening to teachers, memorizing pre-packaged assignments, and spitting out answers. They must talk about what they are learning, write about it, relate it to past experiences, apply it to their daily lives. They must make what they learn part of themselves.

(Chickering & Gamson)

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ACTIVE AN

ACTIVE LEARNING

Engages students directly in thinking and problem solving activities
Emphasis on engaging students in manipulating, applying, analyzing, and evaluating ideas

Examples:
Pair-and-Share
Group discussions
Debates
Concept questions

EXPERIENTIAL LEARNING

Active learning in which students take on roles that simulate professional engineering practice

Examples:
Design-implement experiences
Problem-based learning
Simulations
Case studies

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Standard 9 - Enhancement of Faculty CDIO Skills

Actions that enhance faculty competence in personal, inter-personal, and product, process and system building skills

Description: CDIO programs provide support for faculty to improve their own competence in the *personal, interpersonal, and product and system building skills* described in Standard 2. They develop these skills best in contexts of professional engineering practice. The nature and scope of faculty development vary with the resources and intentions of different programs and institutions. Examples of *actions that enhance faculty competence* include: professional leave to work in industry, partnerships with industry colleagues in research and education projects, inclusion of engineering practice as a criterion for hiring and promotion, and appropriate professional development experiences at the university.

Enhancement of Staff CDIO Skills……..

What do I need to do for this?

Standard 10 - Enhancement of Faculty Teaching Skills

Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning

Description: A CDIO program provides support for faculty to improve their competence in *integrated learning experiences* (Standard 7), active and experiential learning (Standard 8), and assessing student learning (Standard 11). The nature and scope of faculty development practices will vary with programs and institutions. Examples of *actions that enhance faculty competence* include: support for faculty participation in university and external faculty development programs, forums for sharing ideas and best practices, and emphasis in performance reviews and hiring on effective teaching skills.

Enhancing my Teaching Skills….

I have been teaching for years,
why do I need more teaching skills?

Standard 11 - CDIO Skills Assessment

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

Description: Assessment of student learning is the measure of the extent to which each student achieves specified learning outcomes. Instructors usually conduct this assessment within their respective courses. Effective learning assessment uses a variety of methods matched appropriately to learning outcomes that address *disciplinary knowledge*, as well as *personal, interpersonal, and product and system building skills*, as described in Standard 2. These methods may include written and oral tests, observations of student performance, rating scales, student reflections, journals, portfolios, and peer and self-assessment.

Integrating Assessment

Assessment is not separate from the instructional process but an integral part of it

Well used assessment methods and processes significantly enhance learning
→ direct learning towards desired learning outcomes
→ provide clear guides to performance criteria & standards

"There have been a number of notable studies over the years which have demonstrated that assessment methods and requirements probably have a greater influence on how and what students learn than any other single factor. This influence may well be of greater significance than the impact of teaching or learning materials" - *Boud*

Learning Assessment

Use of **Formative Assessment** (i.e. to support learning, not grading) provides a means in which students and lecturers can receive important feedback which can facilitate:

- clarifying what good performance is (e.g. goals, criteria, standards)
- identifying gaps in performance and specific learning needs
- closing gap between current and desired performance
- positive beliefs and self-esteem
- development of self-assessment in learning
- appropriate modification of teaching and learning strategy

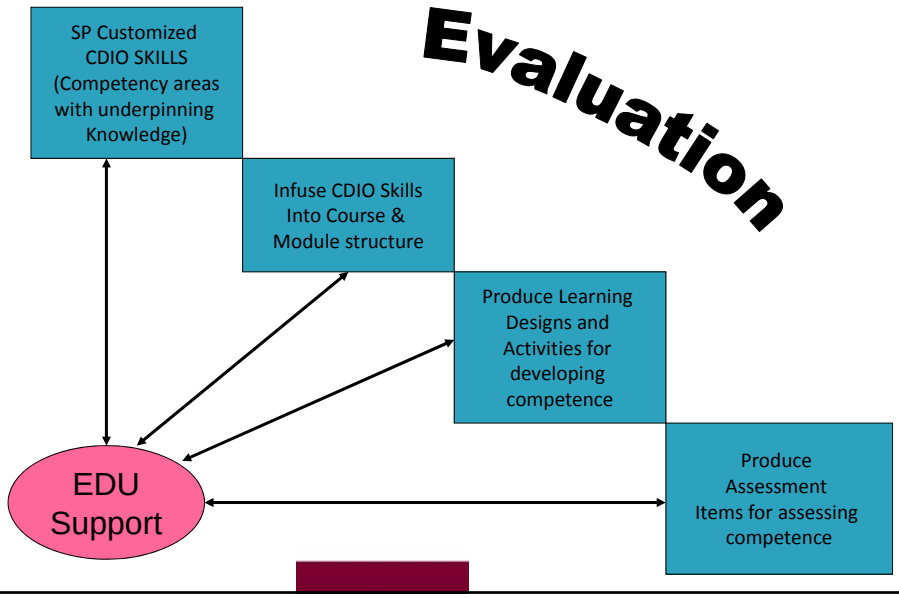
Standard 12 - CDIO Program Evaluation

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

Description: Program evaluation is a judgment of the overall value of a program based on evidence of a program's progress toward attaining its goals. A CDIO program should be evaluated relative to *these 12 CDIO Standards*. Evidence of overall program value can be collected with course evaluations, instructor reflections, entry and exit interviews, reports of external reviewers, and follow-up studies with graduates and employers. The evidence can be regularly reported back to instructors, students, program administrators, alumni, and other key stakeholders. This *feedback* forms the basis of decisions about the program and its plans for *continuous improvement*.

You like it, but what have you learned?

Implementation: Overview

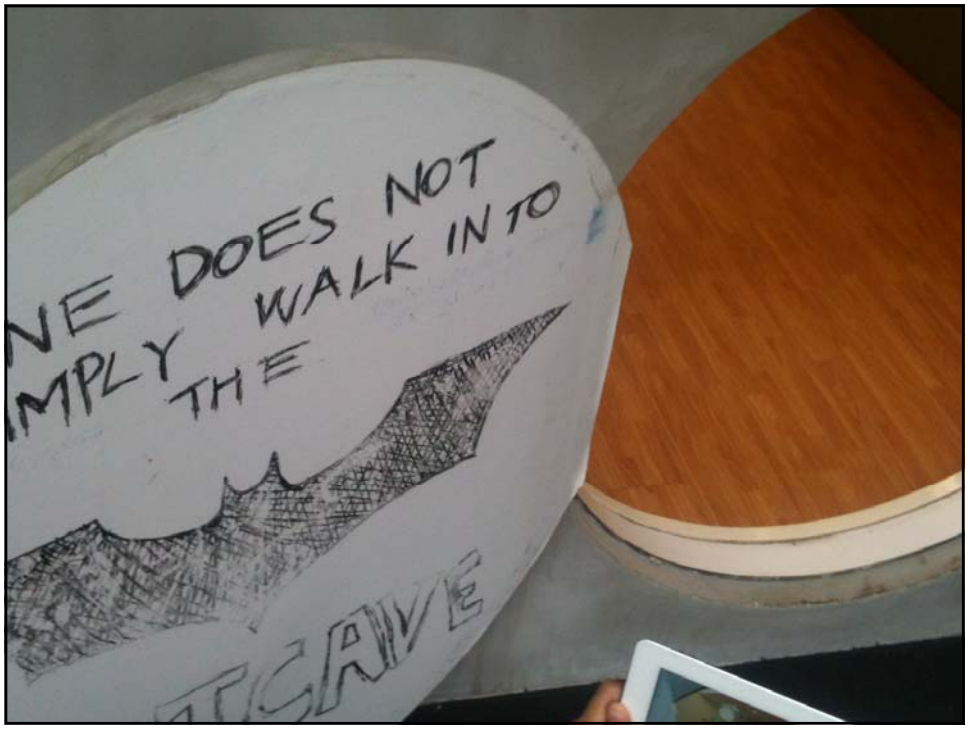


Q & A


cdio
ASIAN
REGIONAL
MEETING
2013


EXIT


BIG
IDEA
SERIES
RIGHT
LEFT
design
thinking
thinking
HOLISTIC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THANK YOU

ENQUIRY:

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cdio

CONCEIVE DESIGN IMPLEMENT OPERATE