CONCEIVE DESIGN IMPLEMENT OPERATE

THE CDIO APPROACH TO ENGINEERING EDUCATION: Designing and Integrating Design-Implement Experiences

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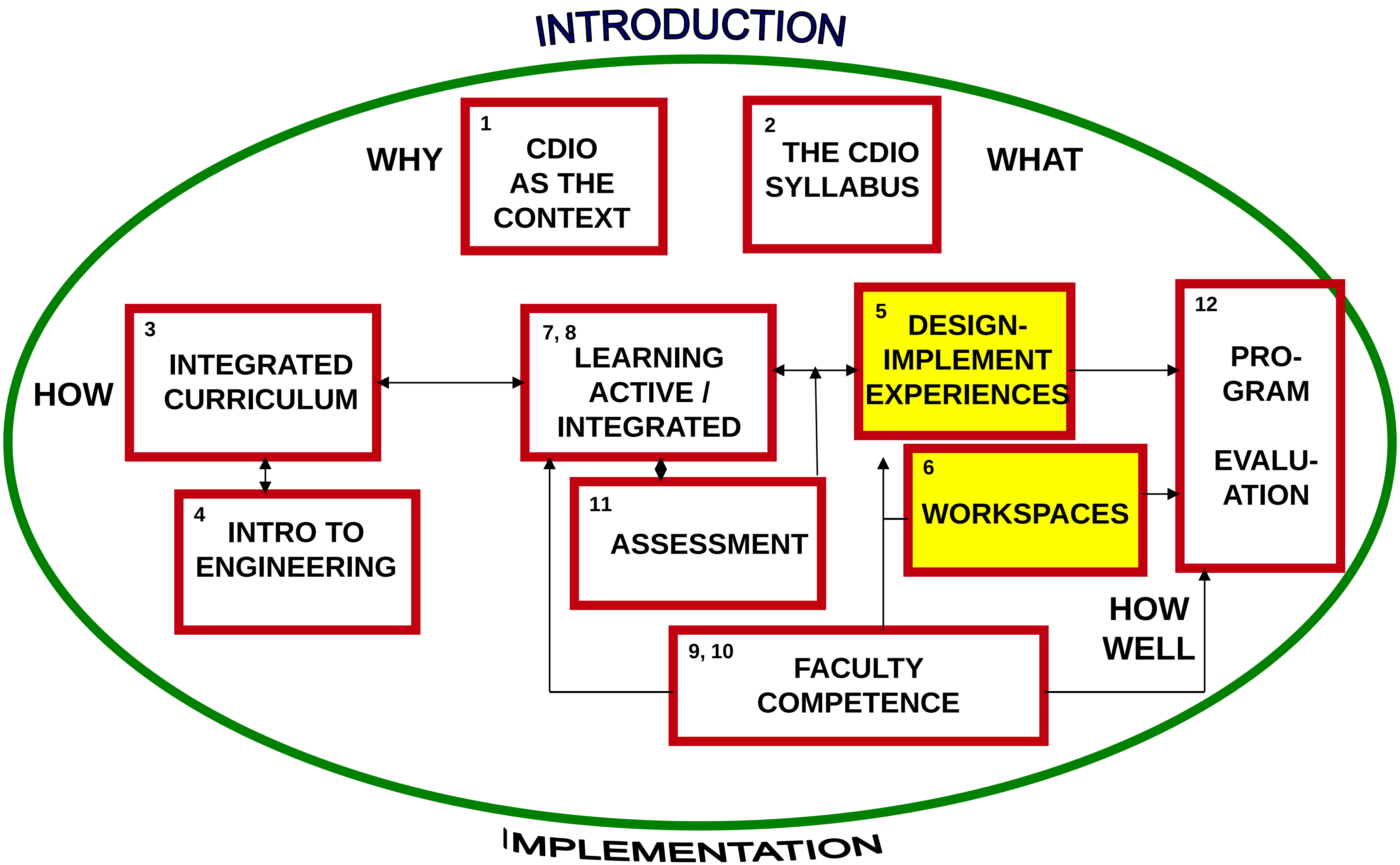
THE TWELVE STANDARDS



SESSION FOUR OBJECTIVES

Explain the rationale for design-implement experiences

Give examples of design-implement experiences in representative CDIO programs

Propose ideas for effective design-implement workspaces

DESIGN-IMPLEMENT EXPERIENCES

Design-implement experiences are instructional events in which learning occurs through the creation of a <u>product</u>, <u>process</u>, or <u>system</u>

- They should be progressed to a state where:
  - they can demonstrate that they meet the requirements
  - potential improvements can be identified
- The level of complexity can vary from basic to advanced
- They may focus on **Conceive**, **Design**, **Implement**, or **Operate**, or any combination of these stages

ALSO KNOWN AS …

Design-Implement Experience*. Also know as …*

- Design-build
- Design-build-test
- Design-build-fly
- Design-build-compete

- Project-based learning
- Icebreaker
- Two-week creation
- Industrial design project

RATIONALE FOR D-I EXPERIENCES

A f… ew… k for stude… o build …

A framework for students to learn engineering by building things

The Design-Implement Experience may change from year-to-year, but the **learning objectives** remain the same

SAMPLE LEARNING OBJECTIVES

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Learning Objectives

Work effectively in a team

Communication

Analyze technical problems

Solve technical problems

Use appropriate eng. methods

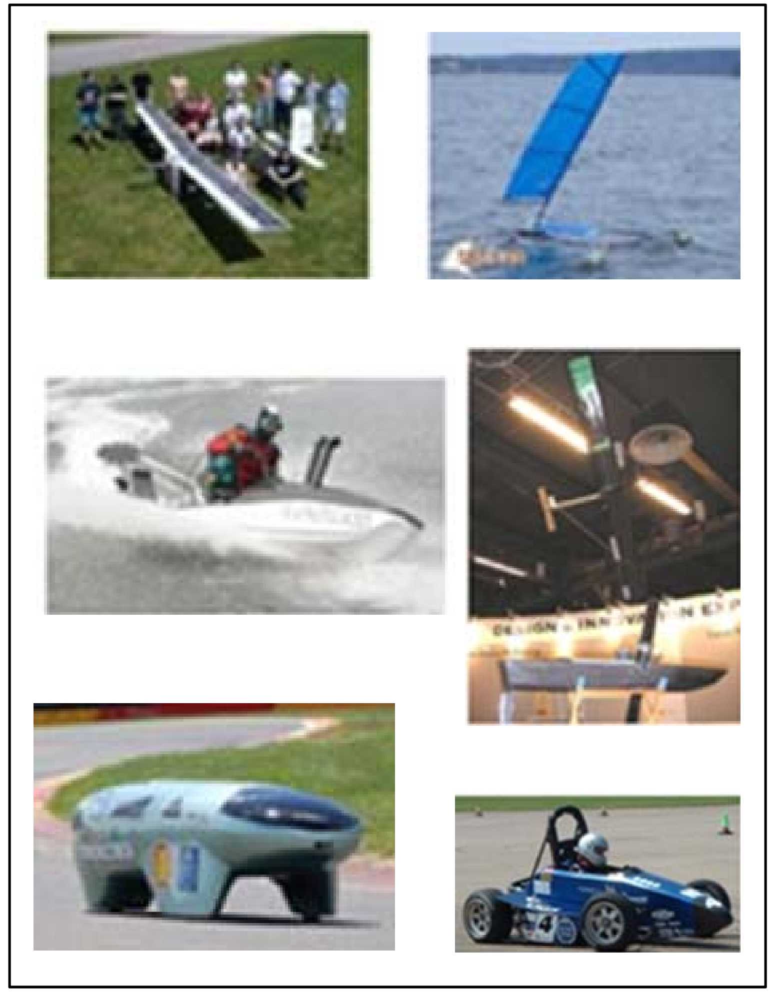
Learn how to make estimates

Develop concepts

Use acquired knowledge

Assess the quality of work

…



Courtesy of KTH

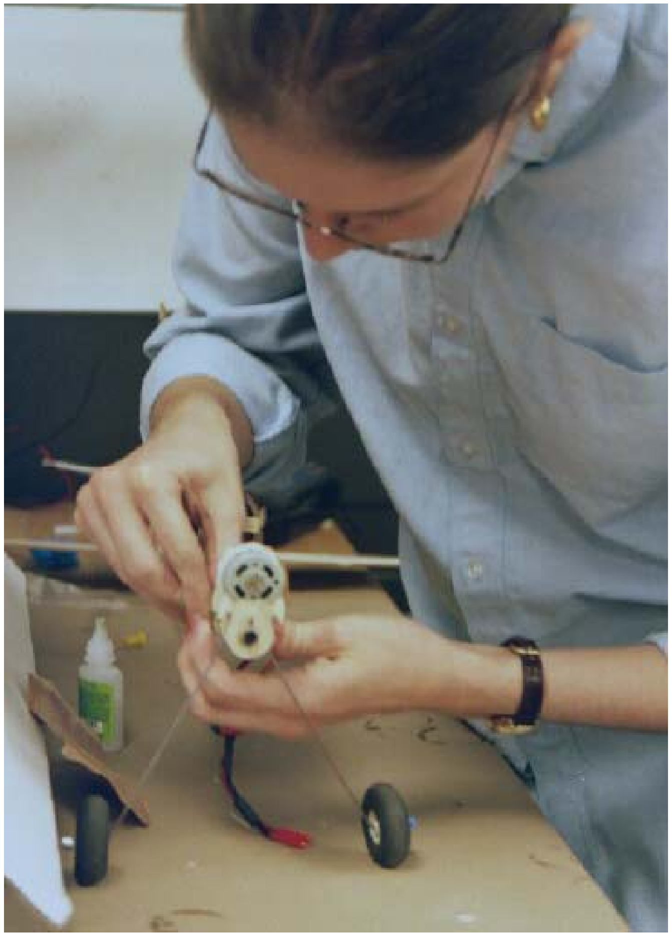
LEVELS OF COMPLEXITY

	Increasing Complexity →		
Activity	I-O	D-I-O	C-D-I-O
Structure	Structured		Unstructured
Solution	Known		Unknown
Team	Individual	Small Team	Large Team
Duration	Days	Weeks	Months

COMPLEXITY LEVEL – LEVEL 1

Building a model airplane from a kit

Activity	I-O
Structure	Structured
Solution	Known
Team	Individual
Duration	Days

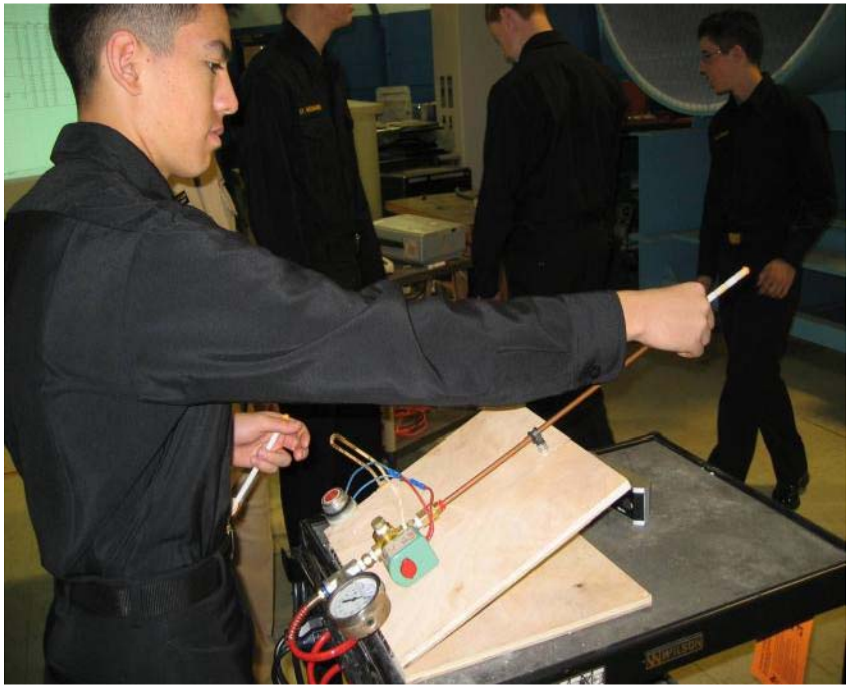


Courtesy of MIT

COMPLEXITY LEVEL – LEVEL 2

Building a model rocket from soda straws

Activity	**(D)-I-O**
Structure	Structured
Solution	Known
Team	**Small Team**
Duration	Days

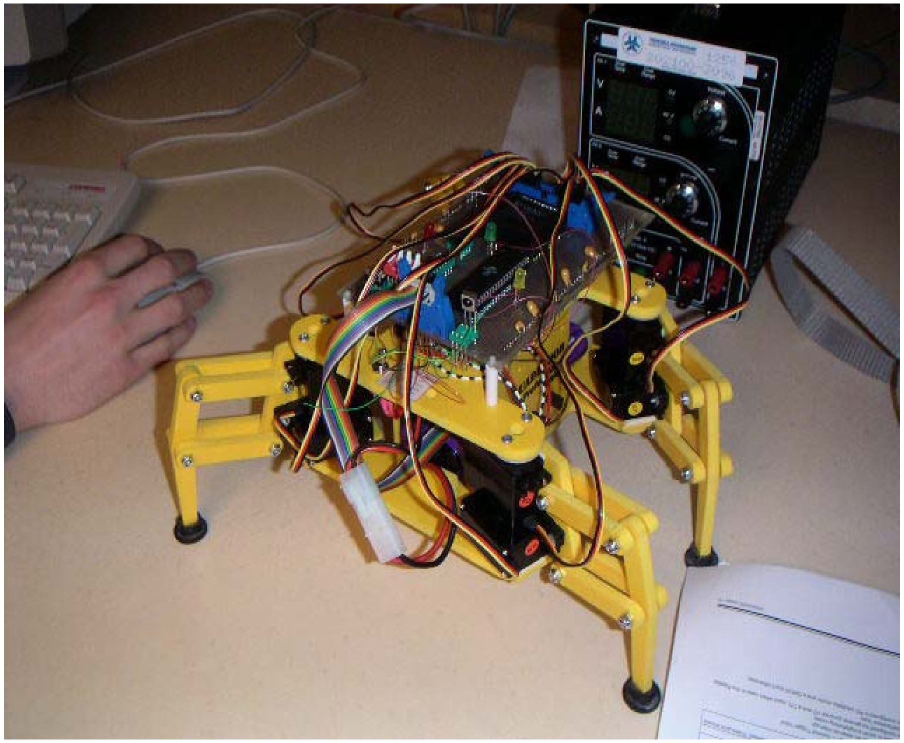


Courtesy of the United States Naval Academy

COMPLEXITY LEVEL - LEVEL 3

Building a robot

Activity	**D-I-O**
Structure	Structured
Solution	**Unknown**
Team	Small Team
Duration	**Weeks/Months**

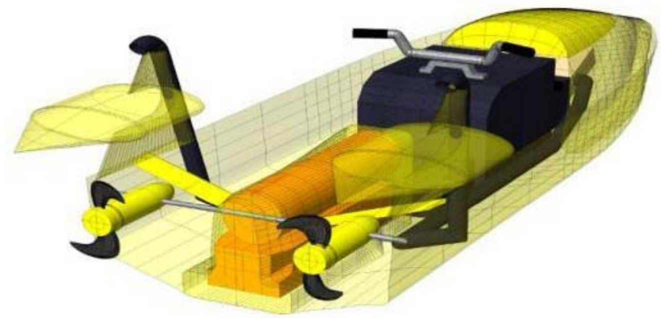


Courtesy of Linköping University

COMPLEXITY LEVEL – LEVEL 4

Sub-skimmer

underwater/overwater craft



Activity	**C-D-I-O**
Structure	**Unstructured**
Solution	Unknown
Team	**Large Team**
Duration	**Months**

Courtesy of KTH

WHAT LEVEL OF COMPLEXITY?

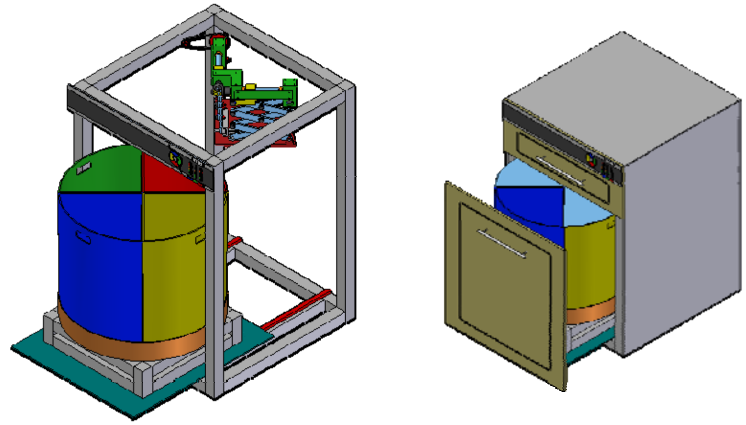
Model Racing Car

Activity	(D)-I-O
Structure	Structured
Solution	Known
Team	Small Team
Duration	Days

Courtesy of Queen's University Belfast

WHAT LEVEL OF COMPLEXITY?

Domestic Recycling Device



Activity	C-D-I-O
Structure	Unstructured
Solution	Unknown
Team	Small Team
Duration	Months

Courtesy of Queen's University Belfast

BEST PRACTICE

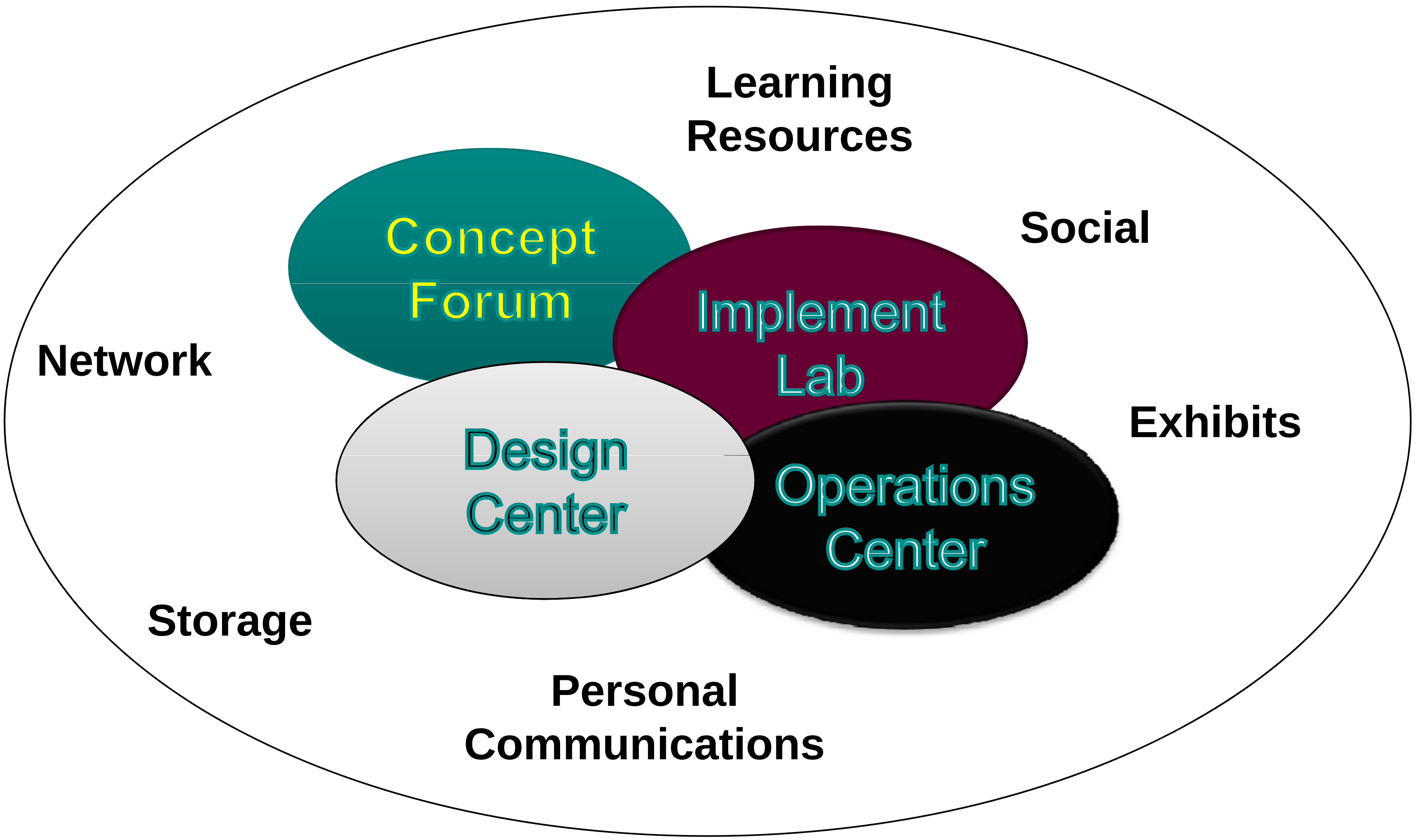
CDIO Standard 5 -- Design-Implement Experiences

A curriculum that includes two or more design-implement experiences, including one at a basic level and one at an advanced level

Design-implement experiences

- Add realism to the curriculum
- Illustrate connections between engineering disciplines
- Foster students’ creative abilities
- Are motivating for students

DESIGNING THE CDIO LEARNING ENVIRONMENT



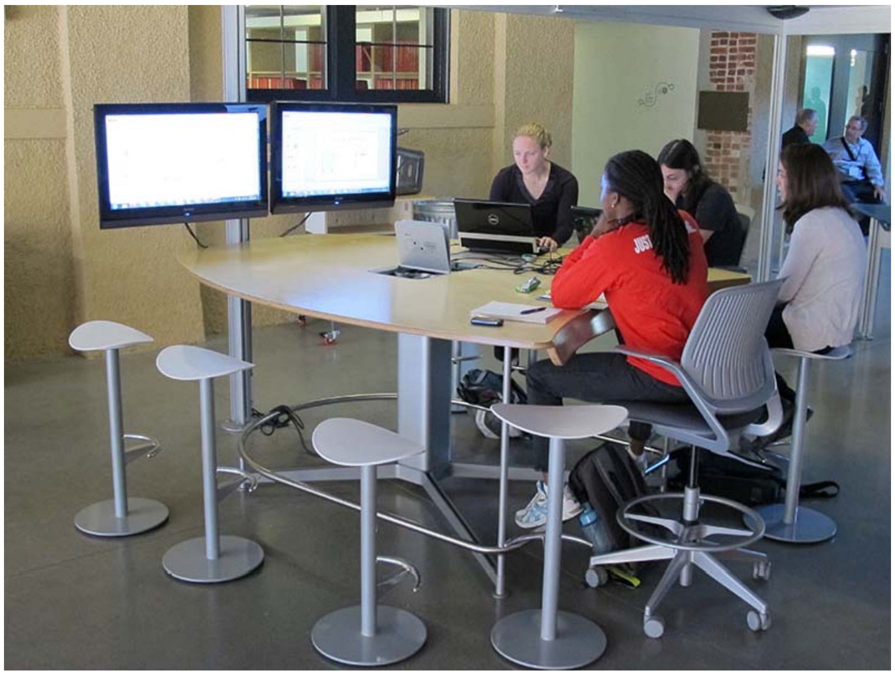
Example: A CDIO Workspace

CONCEIVE SPACE

- Allows students to envision new systems, understand user needs, and develop concepts
- Emphasizes reflections
- Reinforces human interaction
- Largely a technology-free zone

Massachusetts Institute of Technology

DESIGN SPACE



Stanford University - dschool

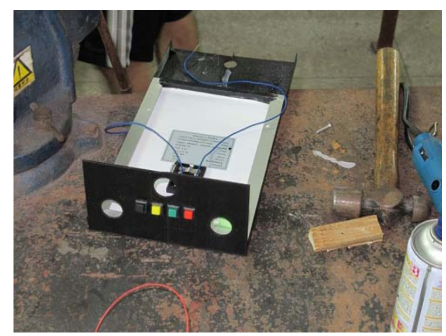
- Model of cooperative digitally supported design
- Allows students to design, share designs, and understand interactions
- Central room and team breakout rooms
- *Design* space is near *Implement* space to reinforce connections

IMPLEMENT SPACE

University of Calgary, Canada

Shantou University, China

- Allows students to build small, medium and large systems
- Mechanical, electronic, and specialty fabrication
- Software engineering and integration
- Safe, yet accessible as much as possible during "student hours"



3D Printing

OPERATE SPACE

University of Calgary / Shantou University Group Study Program

- Opportunities for students to learn about operations
- They can operate their own experiments and projects
- They can operate facility class experiments
- Provides simulated operations of real systems

WORKSPACE USAGE MODES

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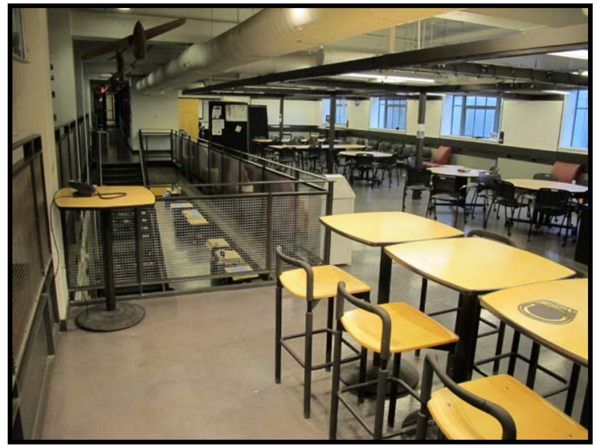
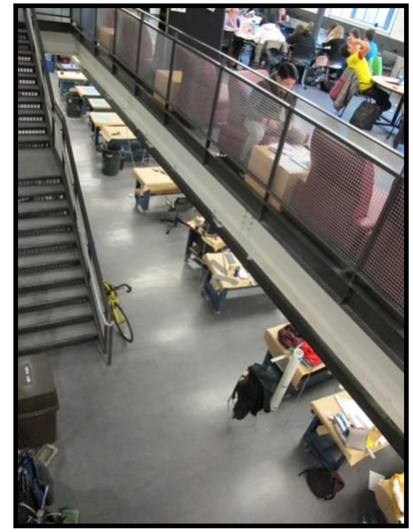
Reinforcing Disciplinary Knowledge

Aero / Astro

Community Building





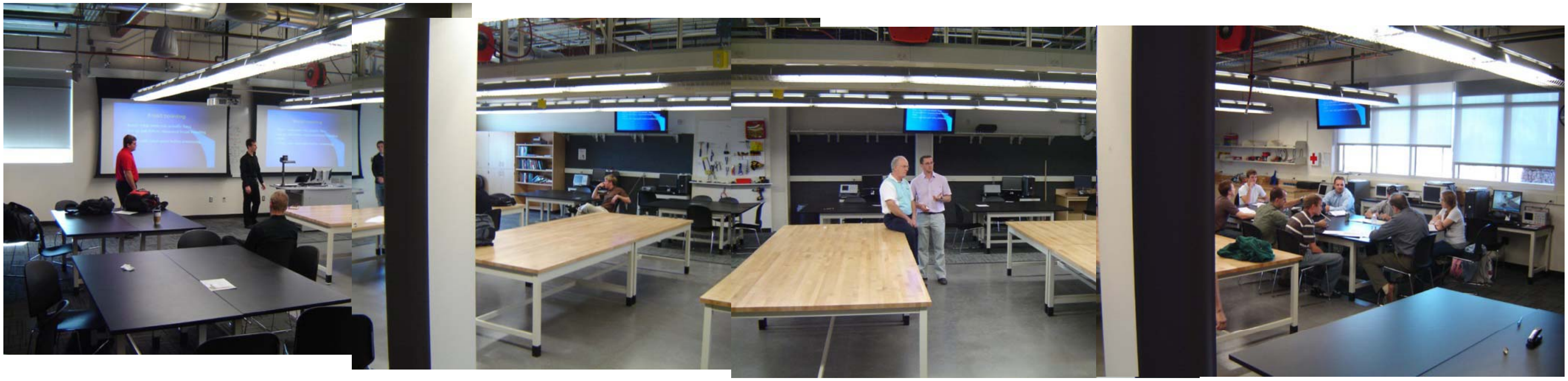
VETENSKAP OCH KONST
KTH

Hangaren

System Building

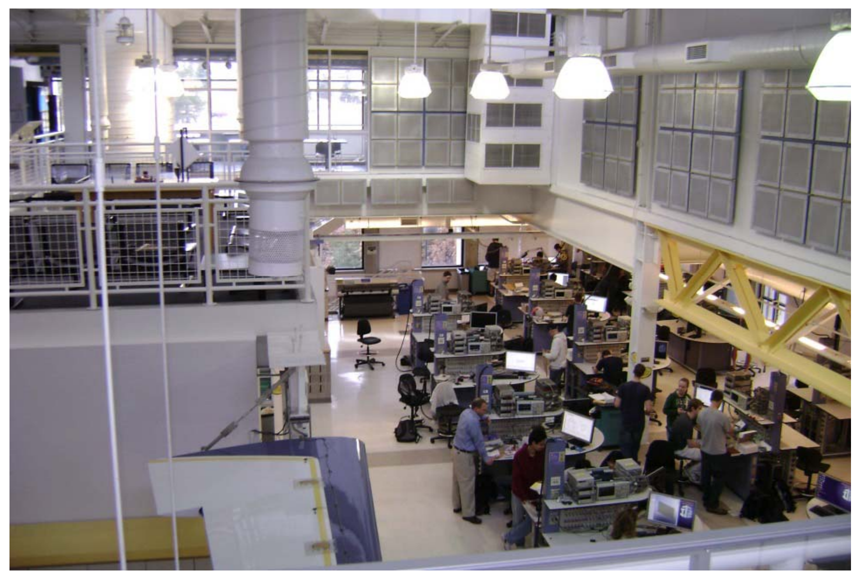
Knowledge Discovery

EXAMPLES OF CDIO WORKSPACE



Arizona State University

University of Liverpool



CU Boulder - ITLL

PRACTICE STUDENT AKIDO

MULTI-YEAR EFFORT

2010 *Shantou University* *2015*

WORKSPACE CONSIDERATIONS

- Flexibility
- Connectivity
- Safety
- Hours of operation
- Staffing
- Security
- Scheduling and use
- Ownership
- Display devices and areas
- Storage of equipment, materials, and works in progress
- Social space
- Furnishings
- Public address areas and systems
- Cost

Chalmers University of Technology

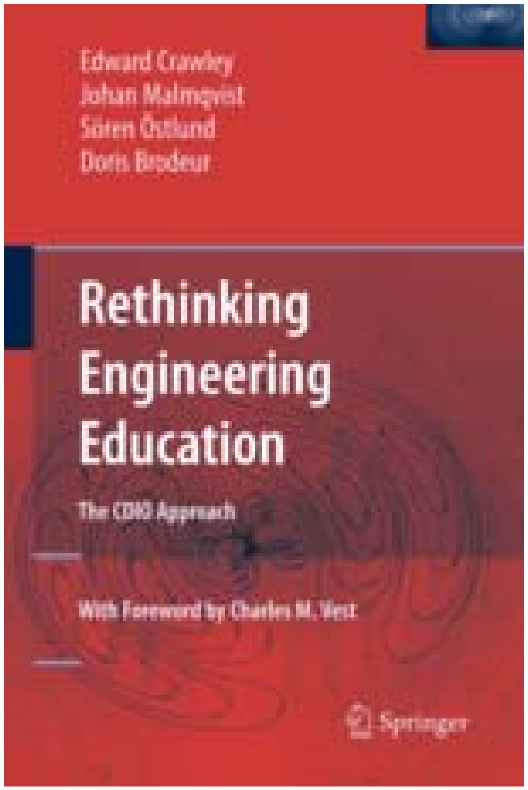
BEST PRACTICE

CDIO Standard 6 - Engineering Workspaces

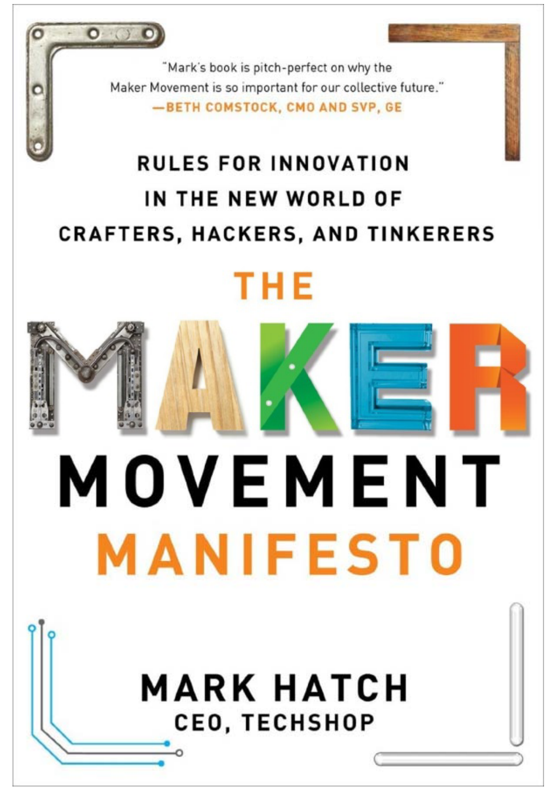
Workspaces and laboratories that support and encourage hands-on learning of product, process, and system building, disciplinary knowledge, and social learning

- Students are directly engaged in their own learning
- Settings where students learn from each other
- Newly created or remodeled from existing spaces

RESOURCES


Edward Crawley
Johan Malmqvist
Sören Östlund
Doris Brodeur
Rethinking Engineering Education
The CDIO Approach
With Foreword by Charles M. Vest
Springer


make space
How to Set the Stage for Creative Collaboration
Scott Doorley and Scott Witthoft
with a foreword by David Kelley


"Mark's book is pitch-perfect on why the Maker Movement is so important for our collective future."
—BETH COMSTOCK, CMO AND SVP, GE
RULES FOR INNOVATION IN THE NEW WORLD OF CRAFTERS, HACKERS, AND TINKERERS
THE MAKER MOVEMENT MANIFESTO
MARK HATCH
CEO, TECHSHOP

BEST PRACTICE: THE 12 CDIO STANDARDS

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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

ACTIVITY: DISCUSSION

1. Describe at least one **basic** and one **advanced** design-implement experience in your curriculum
2. Identify the challenges to implementing these experiences for students
3. What evidence do you have that these experiences are effective and beneficial?

University of Calgary / Shantou University Group Study Program

ACTIVITY: RATING THE CHALLENGES

What are the main challenges to designing and integrating design-implement experiences in your program?

CHALLENGE	A BIG CHALLENGE	A MODERATE CHALLENGE	NOT SO DIFFICULT
Assessing success in products separately from success in learning			
Finding projects that are at the right level -- complex, but within students' ability to succeed			
Finding appropriate teaching and assessment methods for project-based courses			
Enhancing faculty competence in design-implement skills and in new teaching roles			
Providing relevant experiences in a cost-effective way			