DESIGN-BUILD EXPERIENCES

Geoff Cunningham

GOALS FOR SESSION

- To introduce the concept of a design-build experience
- To explain the relationship between CDIO and design-build experiences
- To provide examples of design-build experiences
- To summarize experiences and lessons learned
- To discuss the potential role and implementation of design-build experiences in the workshop participants' programs

WHAT IS A DESIGN-BUILD EXPERIENCE?

Design-build experiences (DBEs) are learning episodes where the learning takes place through the creation of a “product”

The product should be developed and implemented to a state where it is operationally testable by students in order to verify that it meets its requirements and to identify possible improvements

The product can be made of hardware, software, or a combination of both

Design-build-test experiences range from “basic” (usable in freshman classes) to “advanced” (requires sophisticated technical knowledge)

WHAT'S IN A NAME

- Design-implement experience

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

CDIO STANDARDS

Standard 1 – CDIO as Context*

… engineers should be able to Conceive, Design, Implement and Operate complex value-added engineering products and systems in modern team-based environments … This is the essence of the engineering profession.

Standard 5 – Design-build Experiences*

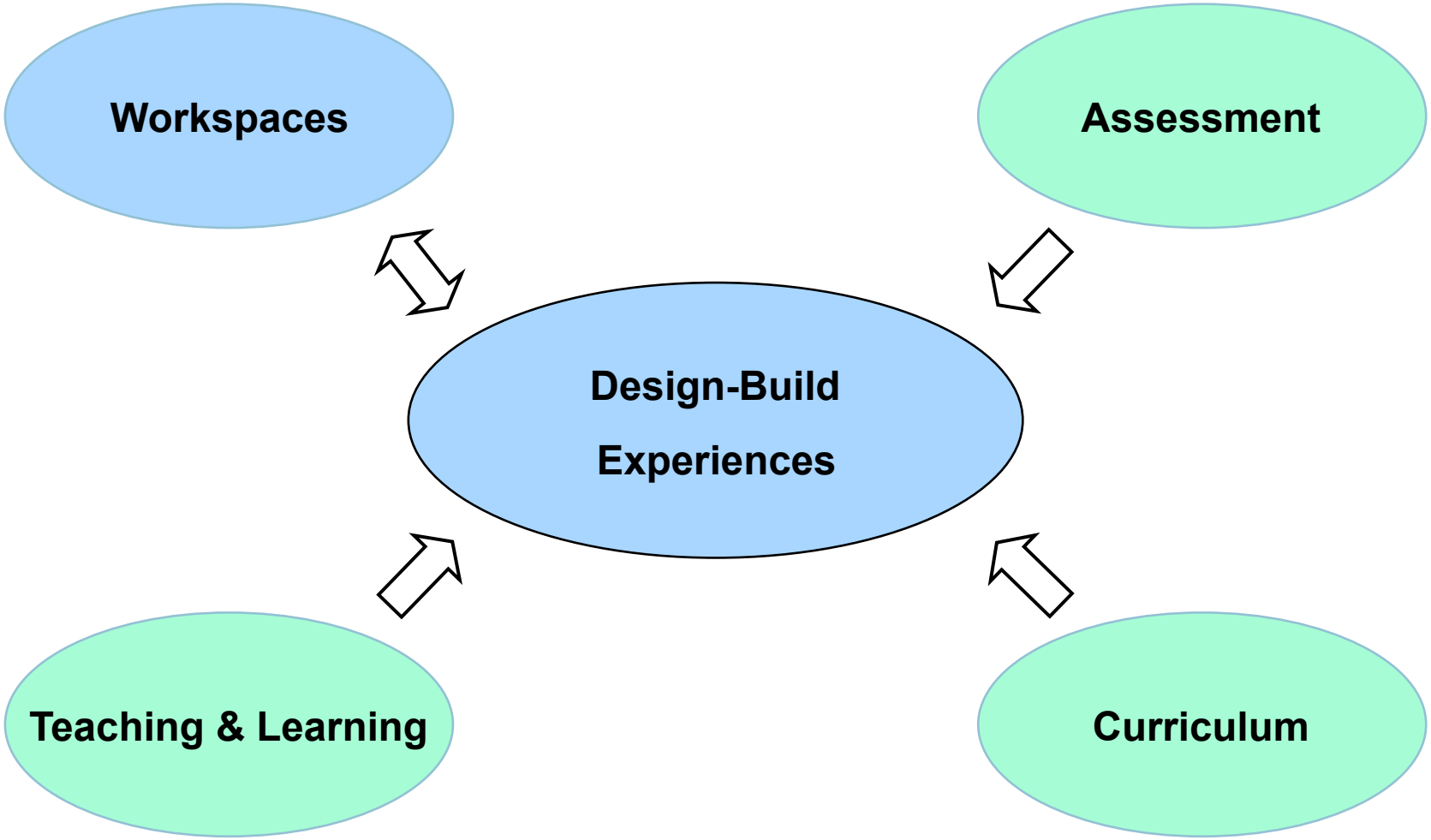
A curriculum that includes two or more design-build experiences, including one at a basic level and one at an advanced level

CDIO AND DESIGN-BUILD EXPERIENCES

Design-build experiences (DBEs) address all of the activities described in Standard One at the Design and Implement stages, plus appropriate aspects of conceptual design from the Conceive stage.

A basic level DBE might happen in the first year of the program, while an advanced level DBE may take place in the last year of the program.

CONTEXT


Workspaces
Assessment
Design-Build
Experiences
Teaching & Learning
Curriculum

BASIC LEVEL DBEs

MIT - Lego Mindstorms "Mars Rovers"

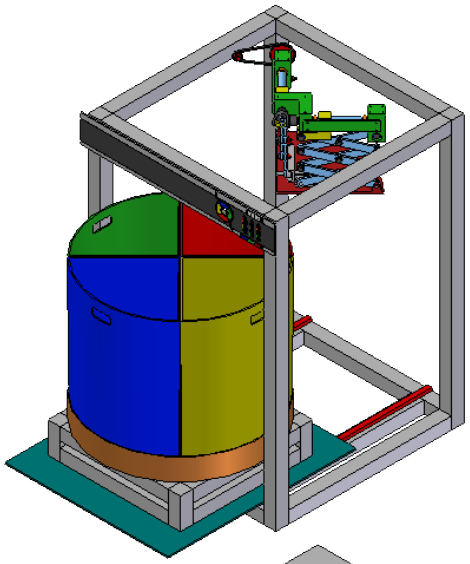
BASIC LEVEL DBEs

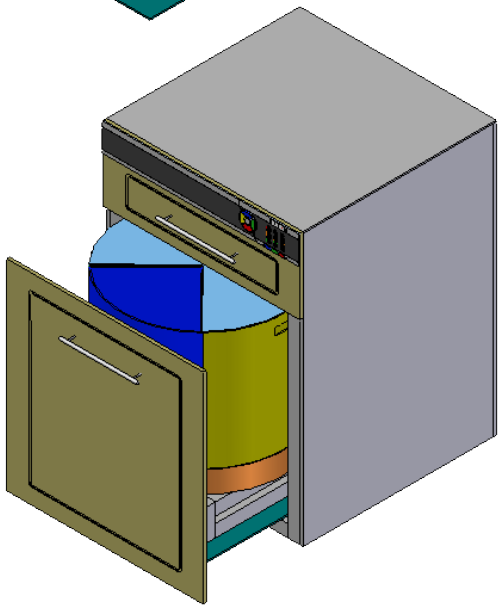
USNA - Soda Straw "Rockets"

BASIC LEVEL DBEs

QUB - Model Racing Car

ADVANCED LEVEL DBEs - SMALL TEAM

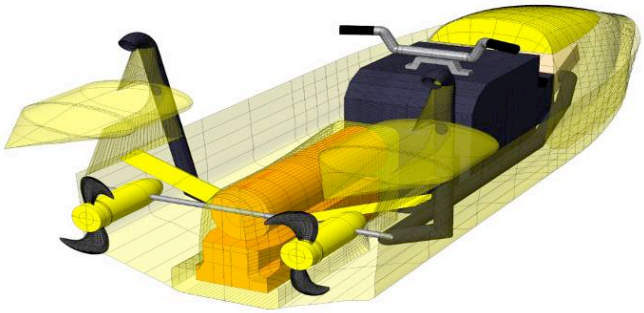




QUB – DOMESTIC RECYCLING DEVICE

ADVANCED LEVEL DBEs - LARGE TEAM

Solar Powered Aircraft



Sub-skimmer

KTH –

Vehicle Engineering Course

ADVANCED LEVEL DBEs - LARGE TEAM

QUB – Formula SAE/Student

Play Video

SURVEY OF DBEs AT PARTNER INSTITUTIONS

'Lessons Learned from Design-Build-Test-Based Project Courses', Malmqvist, Young, Hallstrom and Svensson.

- 13 DBE courses at 4 universities
- All at advanced level ~ 3rd/4th year of program
- Most started after the year 2000

SURVEY FINDINGS (1)

Learning Objectives

- Train conceive-design-implement-operate skills in a realistic environment
- Give insight into the multi-disciplinary aspects of engineering systems
- Strengthen disciplinary knowledge

Characteristics of DBE task

- Most design, build and test vehicles (ground, sea, air)
- Based on mechanics, electronics and software
- Minority consider industrial design, ergonomics and manufacture

SURVEY FINDINGS (2)

Curriculum

- One DBE cannot cover the whole curriculum
- A series of coordinated DBEs will provide better coverage of the curriculum
- DBEs can provide a backbone for a number of lecture courses

Teaching & Learning Methods

- Typically based on a limited number of lectures and a high degree of tutoring
- Industry speakers are common
- Information taken from a range of books plus specific lecture notes

SURVEY FINDINGS (3)

Team Composition

- Team size varies widely between 3 and 30
- Team selection by students and/or staff
- Small team size
  - Emphasis on technical problem solving
  - Avoids student over-specialisation
  - Magnifies pressure to work
- Large team size
  - Emphasis on project management and communication
  - More realistic multi-disciplinary tasks
  - Risk of student specialisation

SURVEY FINDINGS (4)

Assessment

- Assess the learning outcomes
- Difficulty concurrently assessing the process and product
  - Good design process but poor product
  - Poor design process but good product
- Various assessment methods exist, but no common approach has been agreed on
  - Assess product OR assess documentation?
  - Individual marks/report OR team marks/report?
  - Peer assessed OR teacher moderated marks?

GUIDELINES (1)

Pre-course planning

- Start well in advance
- Educate academic supervisors
- Plan for renewal of projects
- Provide dedicated space
- Create links with other courses
- Build on earlier DBEs

GUIDELINES (2)

Designing the design-build task

- Customer involvement will motivate students
- Clearly define learning objectives
- Teach/assess learning objectives through project deliverables
- Choose an appropriate level of difficulty
  - Too difficult ~ teacher creates, student implements
  - Too simple ~ reduced motivation and sense of achievement
- Have multiple paths between the start and end to stimulate creativity
- Include non-technical skills e.g. communication

GUIDELINES (3)

Course execution

- Carefully consider team size
- Plan for checkpoints to track progress
- Include assessment tasks at an early stage
- Include self-evaluation of project success
- Include adequate training on the use of tools and equipment

DISCUSSION

Challenges:

What are the most challenging aspects of implementing a DBE?

Issues:

What difficulties do you foresee during the running of DBEs?

CHALLENGES

What are the most challenging aspects of implementing a DBE?

CHALLENGES

How can we develop cost-effective design-build experiences?

- Faculty time
- Money
- Floor space

What are most suitable ways of assessing design-build experiences?

How do we create curriculum links to exploit early basic design-build experiences and strengthen technical knowledge?

ISSUES

What difficulties do you foresee during the running of DBEs?

ISSUES

- Faculty competence (managing DBEs)
- Generation and renewal of project ideas
- Stating the design-build task with an appropriate level of difficulty
- Avoiding overspecialization by students – only using skills that they already have e.g. CAD
- Other courses may be down-prioritized by students
- Constraints from educational system e.g. timetabling project periods
- Managing internal team conflict
- Creative (risky) solution -v- safe (guaranteed performance) solution
- Student training and supervision for hands-on activities
- Project management

SUMMARY

Design-build experiences (DBEs) are an integral part of a CDIO program

- Train core product and system building skills
- Strengthen engineering science disciplinary learning
- Provide a platform for development of personal and professional skills
- Increase motivation for engineering