CONCEIVE DESIGN IMPLEMENT OPERATE

THE CDIO APPROACH TO ENGINEERING EDUCATION: 2. Designing An Integrated Curriculum

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SESSION TWO OBJECTIVES

Explain the rationale
for an integrated curriculum

Plan ways to benchmark
an existing curriculum

Describe the process for
designing and implementing
an integrated curriculum

CDIO IS NOT A COOKIE CUTTER APPROACH

CDIO is a *reference model*

Everything has to be *translated-transformed* to fit the context and conditions of each university / program

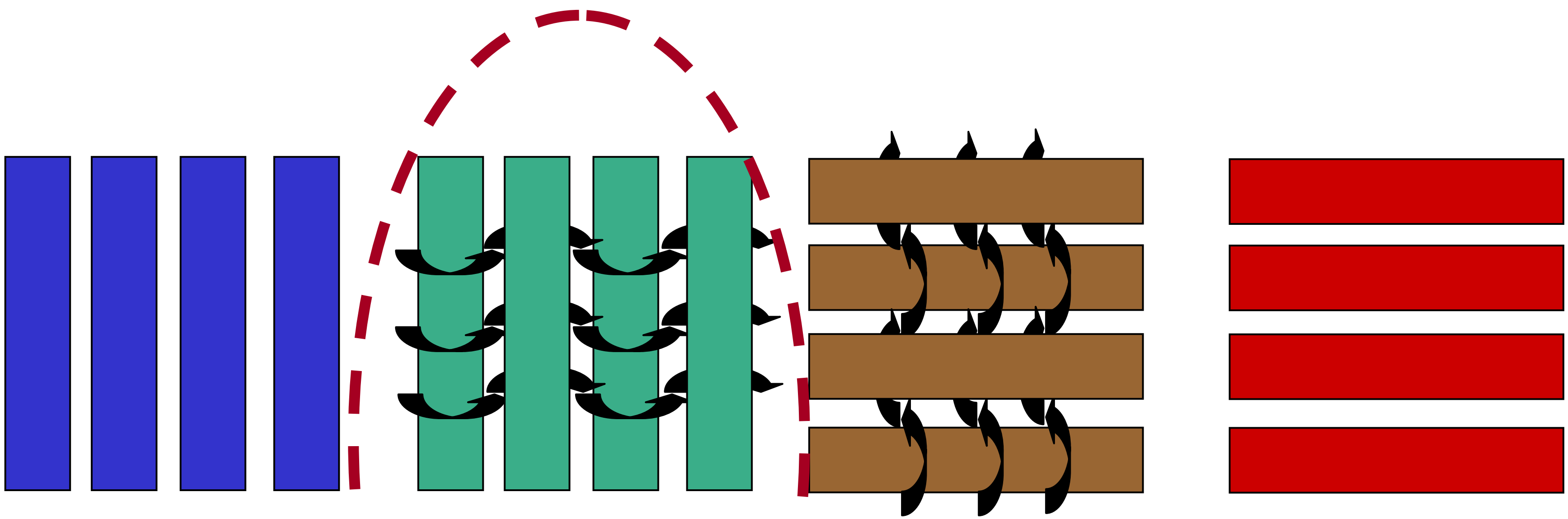
Take what you want to use, transform it as you wish, give it a new name

CDIO provides a toolbox for working through the process

Local faculty ownership is key

CURRICULUM MODELS

(Disciplines run vertically; projects and skills run horizontally.)



A strict disciplinary curriculum
Organized around disciplines, with no explicit introduction of skills

An integrated curriculum
Organized around disciplines, but with skills and projects interwoven

A problem-based curriculum
Organized around problems, but with disciplines interwoven

An apprenticeship model
Based on projects, with no organized introductions of disciplines

THE INTEGRATED CURRICULUM

SYSTEMATIC PROGRESSION OF SKILLS DEVELOPMENT				
Year 1	Course A	Course B	Course C	Course D
Year 2	Course E	Course F	Course G	Course H
Year 3	Course I	Course J	Course K	Course L
Year 4	Course M	Course N	Course O	Course P
Year 5	Course Q	Course R	Course S	Course T
	Oral communi-cation	**Teamwork**	**Project planning**	**Written communi-cation**

(Schematic)

ENGINEERING SKILLS - EXAMPLE

Communication in engineering means being able to

- Use technical concepts comfortably
- Discuss a problem of different levels
- Determine what is relevant to the situation
- Argue for, or against, conceptual ideas and solutions
- Develop ideas through discussion and collaborative sketching
- Explain technical matters to different audiences
- Show confidence in expressing oneself within the field

The skill is embedded in the technical context.

The same contextualised interpretation should be made for teamwork, problem solving, professional ethics, and other engineering skills.

”It’s about educating engineers who can actually engineer!”

IMPLICATIONS - ENGINEERING SKILLS

- **It's not about "soft skills"**

  Personal, interpersonal, product, process, and system building skills are **intrinsic to engineering** and we should recognise them as **engineering skills**.

- **It's not about "adding more content"**

  Students must be given opportunities to develop communication skills, teamwork skills, etc. This is best achieved through **practicing, reflecting, and giving and receiving feedback** (rather than lecturing on psychological and social theory).

- **It's not about "wasting credits"**

  When students practice engineering skills they apply and express their technical knowledge. As they expose their understanding among peers, doing well will also matter more to them. Students will develop **deeper working knowledge**.

- **It's not about appending "skills modules"**

  Personal, interpersonal, product, process, and system building skills must be practiced and assessed **in the technical context**, it cannot be done separately.

INTEGRATED LEARNING
- SO WHO SHOULD TEACH?

Engineering faculty

Faculty show their own competence in skill areas and serve as role models

Identify the faculty who are most willing and best able to teach skills

Faculty must show commitment to engineering skills - they are important and legitimate in education

The nature of skills depends on the context in which they are taught and assessed - it must be authentic

Students working knowledge of technical content is reinforced through the practise of engineering skills - they need support and feedback in both

Skills experts

Experts supporting faculty in their own skills development

Experts coaching faculty in how to support student development of skills

Experts and faculty collaborate in course development

Experts and faculty teaching together

Experts giving students individual support

Experts and faculty giving feedback together

BEST PRACTICE

CDIO Standard 3 -- Integrated Curriculum

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

- Disciplinary courses or modules make explicit connections among related and supporting content and learning outcomes
- Explicit plan identifies ways in which the integration of engineering skills and multidisciplinary connections are to be made

(See Handbook, p. 6)

CDIO 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

- Curriculum design and learning outcomes can be realized only if the teaching and learning experiences make dual use of student learning time
- Faculty serve as role models in teaching product, process, and system building skills as the same time as engineering principles and theory

(See Handbook, p. 10)

The CDIO curriculum design process

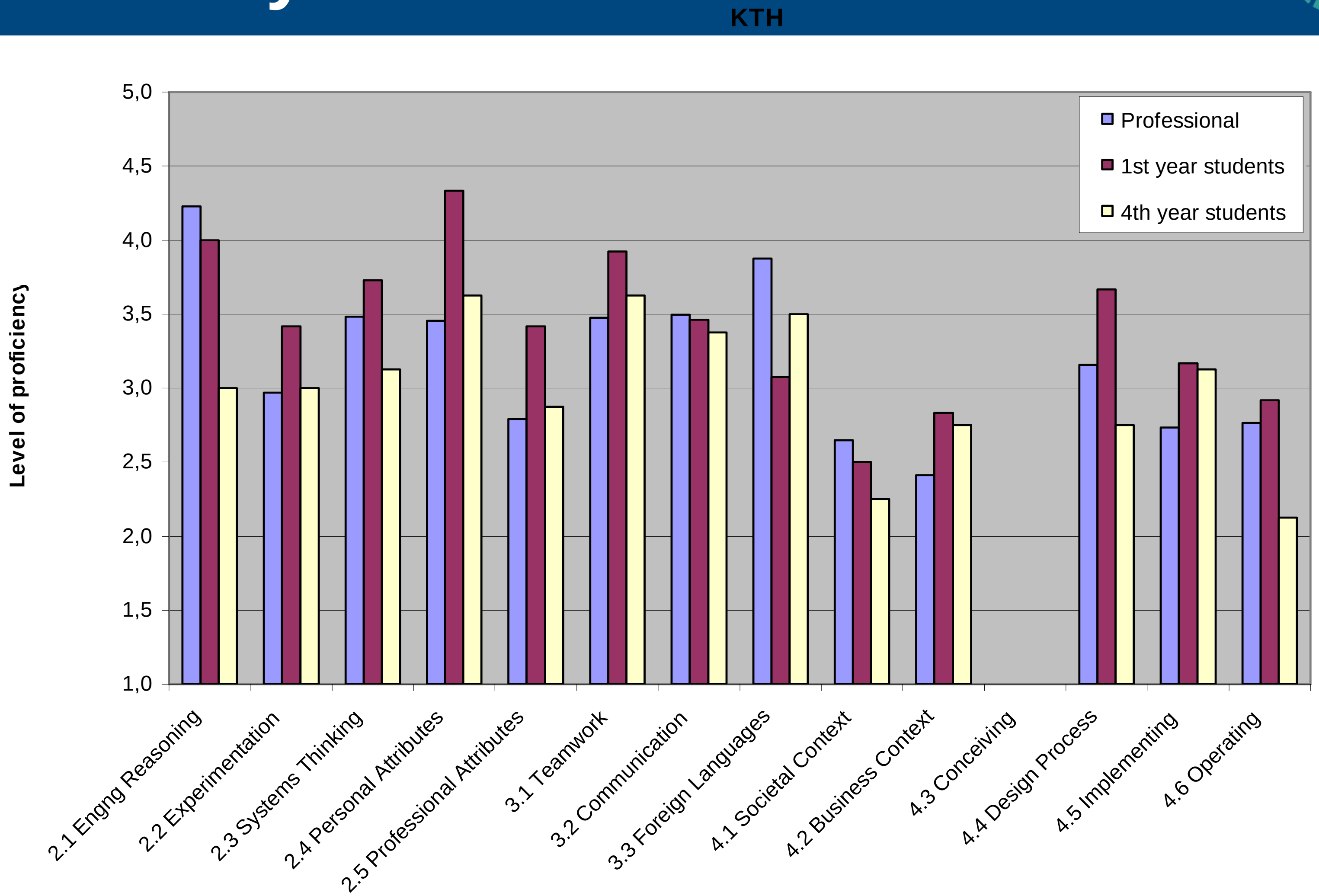
Starting point I: Validation

What learning outcomes should be prioritized *in this program*?

Validate plans with your stakeholders

- **alumni**
- **students**
- **industry**
- **accreditation bodies**
- **government/society**
- **faculty**
- **...**

Survey data



[Benchmarking Engineering Curricula with the CDIO Syllabus. Bankel et al. (2005) *The International Journal of Engineering Education*, Vol. 21 No. 1, 2005.]

Starting point II: Existing curriculum

- Benchmark the existing curriculum for the inclusion of CDIO learning outcomes and topics
- Benchmark existing teaching, learning, and assessment practices
- Benchmark the availability and use of existing workspaces and facilities

METHODS

- Interviews
- Focus groups
- Written questionnaires or surveys
- Comparative studies with peer institutions
- Examination of “best practice” programs
- Reviews of published data

SAMPLE TOOLS

SAMPLE #1

FOCUS: Benchmarking the inclusion of CDIO learning outcomes in the curriculum

METHOD: Structured interviews and surveys

RESPONDENTS: Faculty and academic staff

KEY QUESTIONS: To what extent are each of the CDIO learning outcomes included in your course? Do you introduce them? Do you explicitly teach them? Do you assume students have already learned them, and proceed to apply (utilize) them?

(See Handbook, pp. 23-24)

SAMPLE #2

FOCUS: Benchmarking the teaching and learning of CDIO learning outcomes at the course or module level

METHOD: Open-ended interviews

RESPONDENTS: Faculty and academic staff

KEY QUESTIONS: What learning outcomes from the CDIO Syllabus do you address? What do you expect students to have learned prior to your course? How do students get feedback on their learning, and how do they use that feedback?

(See Handbook, p. 25)

CURRICULUM STRUCTURE

1. Change the course structure?

2. Retask existing courses?

3. Create new courses?

SAMPLE STRUCTURES

Conventional

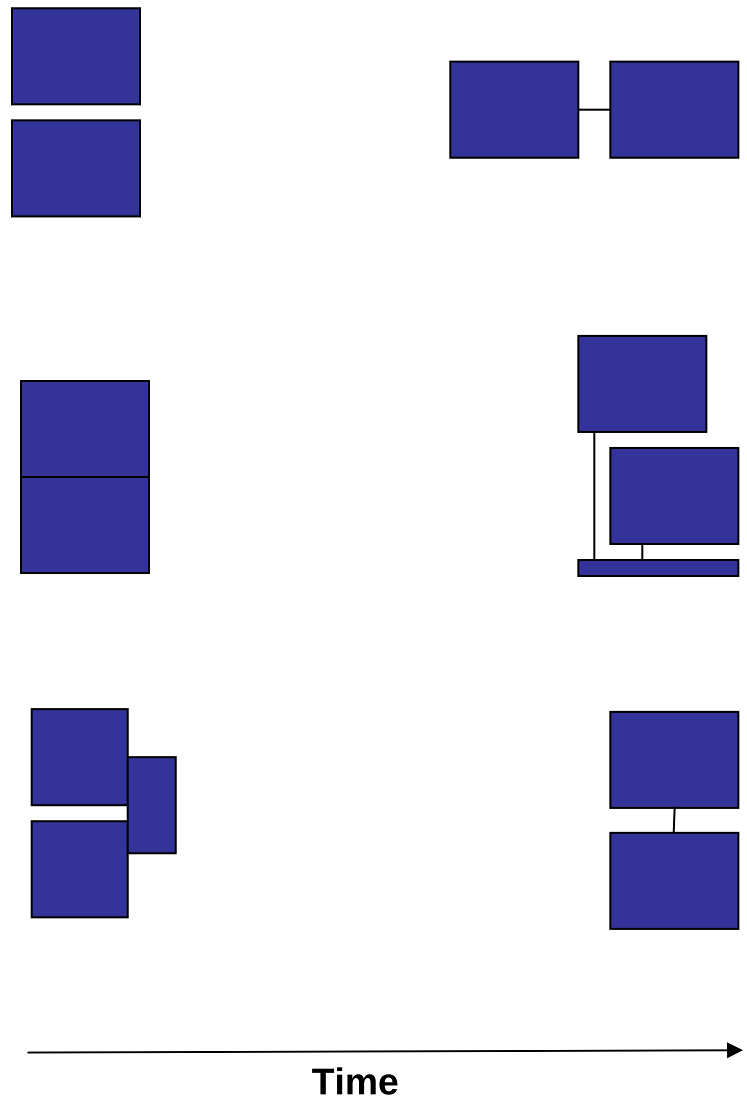
Sequential

Block

Bus or Backbone

Linked/merged

Simultaneous



SEQUENCING ENGINEERING SKILLS

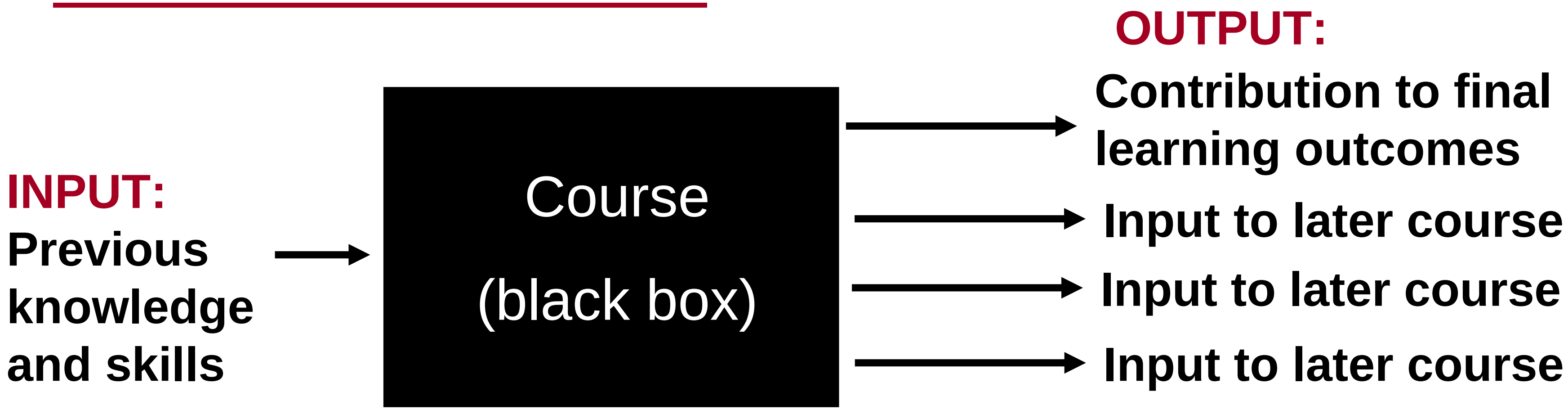
(Based on the curriculum in the Aeronautics and Astronautics program at MIT)

3.2 Communications

SEQUENCE	MAPPING
Write short individual structured reports. Create sketches, charts and simple graphics. Practice simple interpersonal communications.	Unified Engineering (16.01 - 16.04)
Write and present individual or small team short reports, such as lab reports.	Thermal Energy (16.05) Controls (16.06) Dynamics (16.08)
Create and use discipline-specific graphical communications.	Professional Area Subjects (PAS)
Write large, individual or collaborative reports of conference quality. Present collaborative oral reports of conference quality. Use appropriate research resources. Implement appropriate communication strategy based on audience and genre.	Experimental Methods (16.621 - 16.622) Capstone Courses (16.821 - 16.822) (16.830 - 16.832)
Write large, collaborative reports of a briefing nature. Present collaborative oral report of conference quality. Use appropriate research resources. Implement appropriate communication strategy based on audience and genre.	Capstone Courses (16.82) (16.83)

SEQUENCING THE CURRICULUM

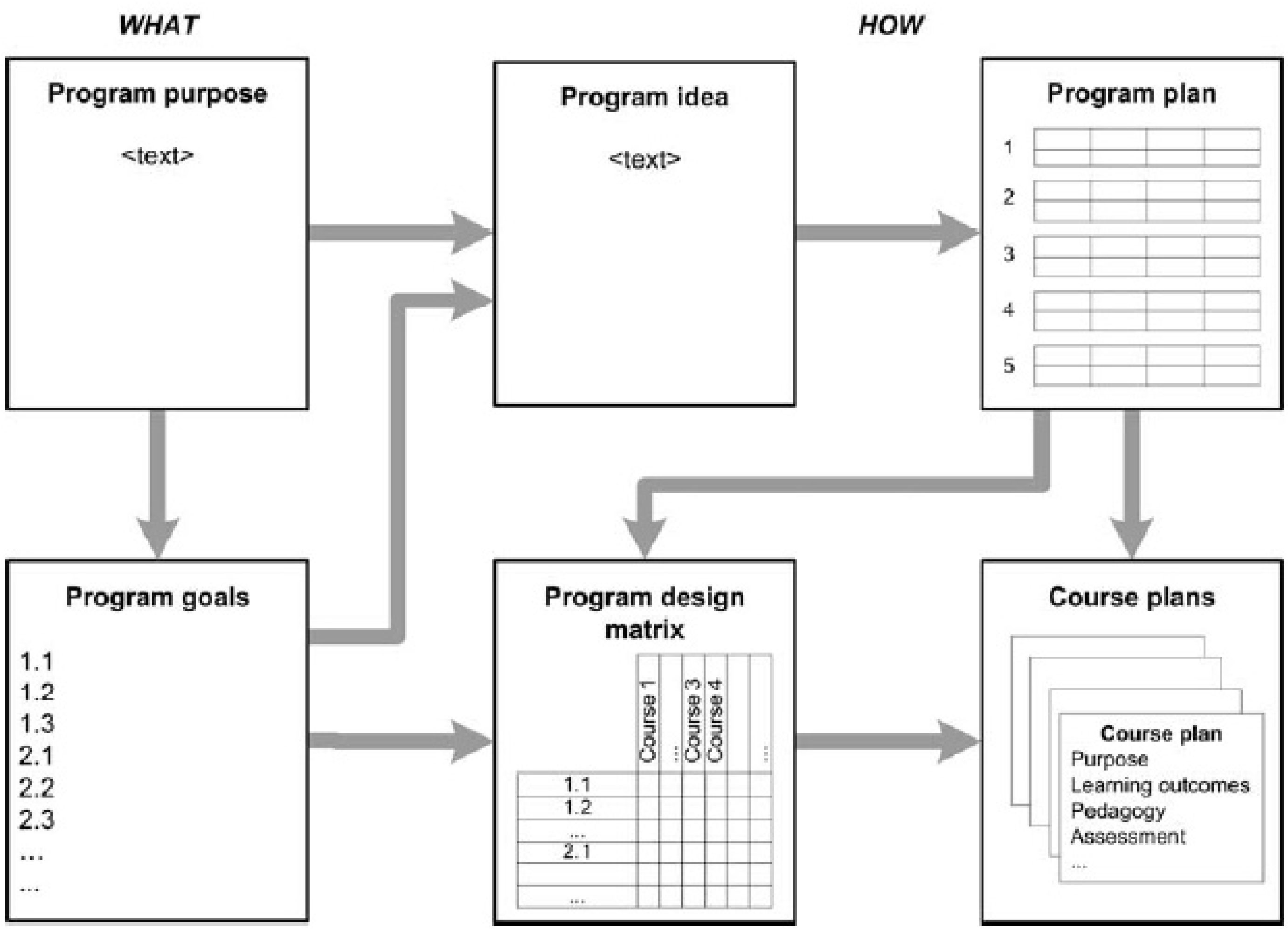
THE BLACK-BOX EXERCISE



All courses are presented through input and output only:

- Enables efficient discussions
- Makes connections visible (as well as lack thereof)
- Gives all faculty an overview of the program
- Serves as a basis for improving coordination
- Use for adjusting intentions in planning phase
- Use for checking existing programs

INTEGRATED PROGRAM DESCRIPTIONS



PROGRAM DESCRIPTION - SAMPLE

FARKOSTTEKNIKPROGRAMMET

Måldokument

Version 1.0
December 2004

VEHICLE ENGINEERING – KTH

Table of contents
Introduction
Program goals
Engineering skills (CDIO Syllabus to second level of detail and associated expected proficiencies)

<u>Program structure</u>
Program plan
Explicit disciplinary links between courses
Program design matrix
Sequences for selected engineering skills

<u>All courses in program</u>
Intended learning outcomes
Contribution to engineering skills

(See Handbook, pp. 27-28)

Course development phase

1. Create new courses or retask existing ones
   - build on existing strengths (consolidate & develop existing learning activities)
   - work with faculty who are willing & able
   - invite proposals rather than give orders

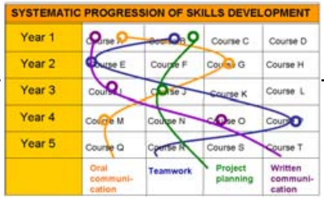
2. Supporting the development
   - allocate resources for course development, give individual support
   - allocate resources for faculty development: individual support, workshops etc

Remember that we are developing the people as much as we are developing the programme

LEVELS OF RESPONSIBILITY

Introduce (I)

Expose the students to a topic. No explicit learning objectives.
No major activities such as assignments, exercises or projects.
No assessment is linked to this topic.



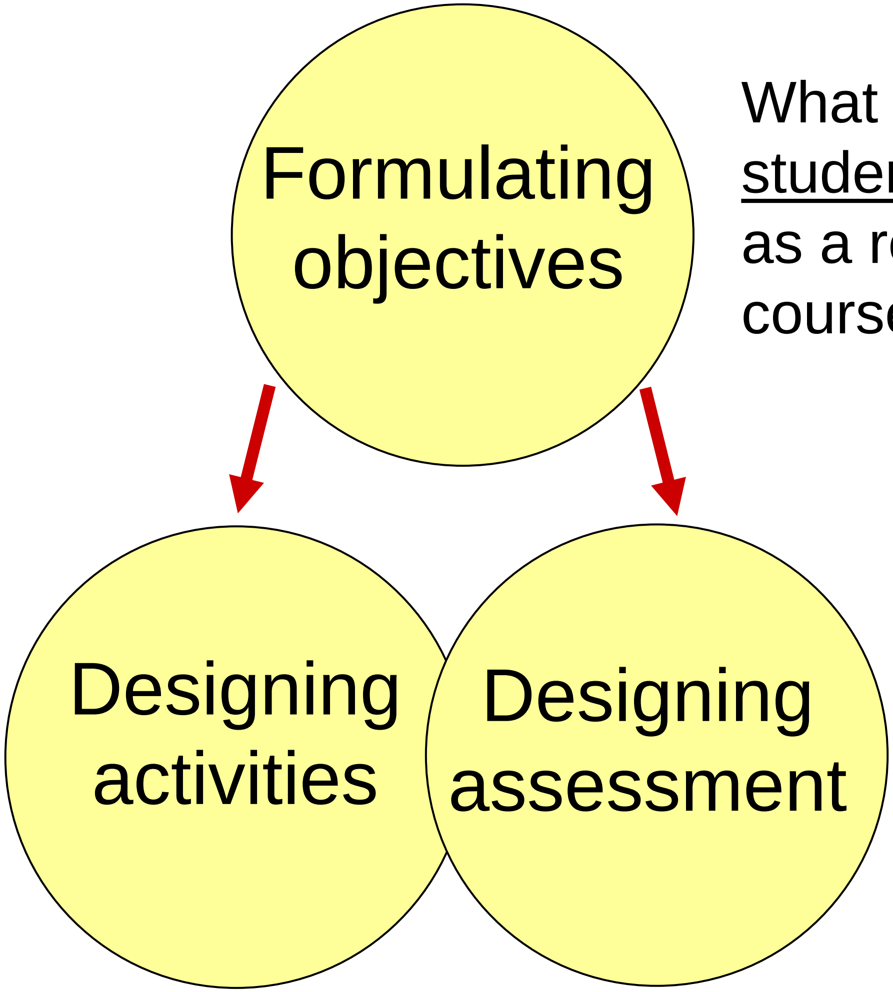
Teach (T)

There is an explicit learning objective.
Compulsory activities, such as assignments, exercises or projects are specifically linked to this topic.
Students are assessed and receive feedback, it may or may not affect grade.

Utilize (U)

Assumes students already have some proficiency in this topic.
It is utilized mainly to learn and/or assess other learning objectives.

CONSTRUCTIVE ALIGNMENT
- A MODEL FOR COURSE DEVELOPMENT



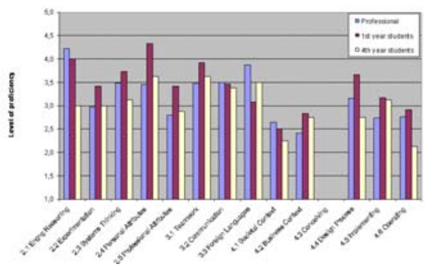
What should the student be able to do as a result of the course?

Constructive alignment, Biggs 1999

What work should the students do, to reach the objectives?

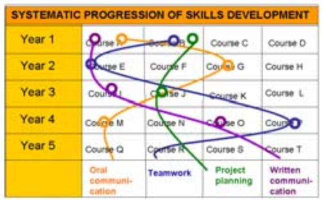
What should the students do, to demonstrate that they reached the objectives?

Process overview

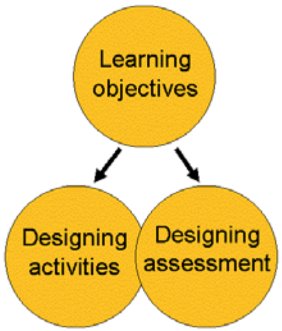


1a. Validation with stakeholders

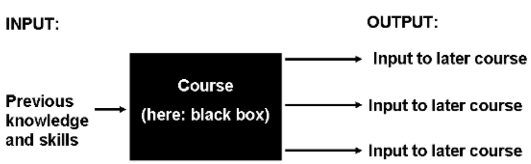
1b. Benchmarking existing courses



2. Mapping of CDIO competences to existing and new courses



3. Course development



4. Fine-tune coordination

ENGINEERING SKILLS

To what extent does your program have clearly documented evidence of where students are taught engineering skills?