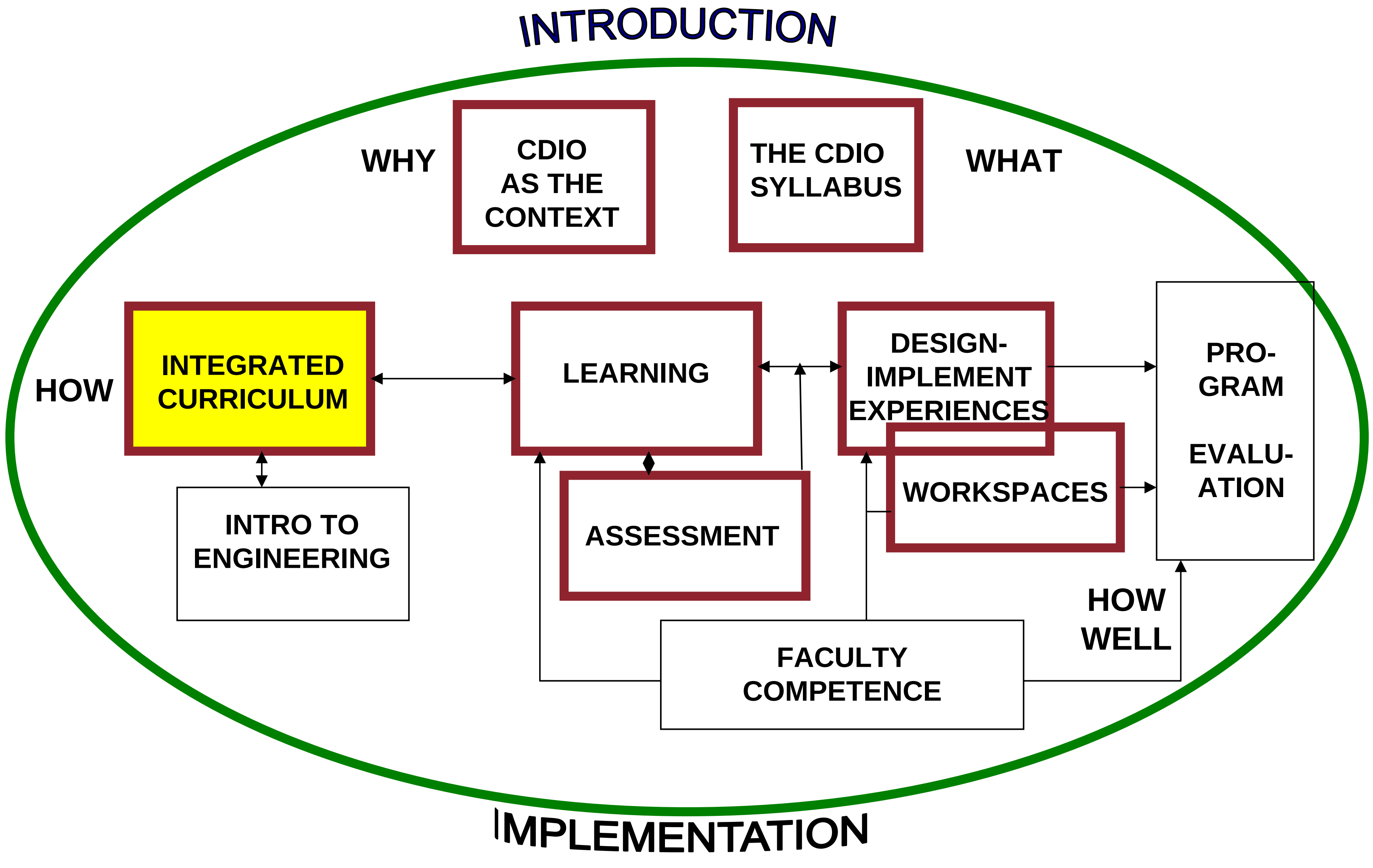
THE CDIO APPROACH TO ENGINEERING EDUCATION: 2. Designing An Integrated Curriculum

Revised January 2008

SESSION TWO



INTRODUCTION
WHY
CDIO AS THE CONTEXT
THE CDIO SYLLABUS
WHAT
HOW
INTEGRATED CURRICULUM
LEARNING
DESIGN-IMPLEMENT EXPERIENCES
PRO-GRAM
EVALU-ATION
INTRO TO ENGINEERING
ASSESSMENT
WORKSPACES
HOW WELL
FACULTY COMPETENCE
IMPLEMENTATION

SESSION TWO OBJECTIVES

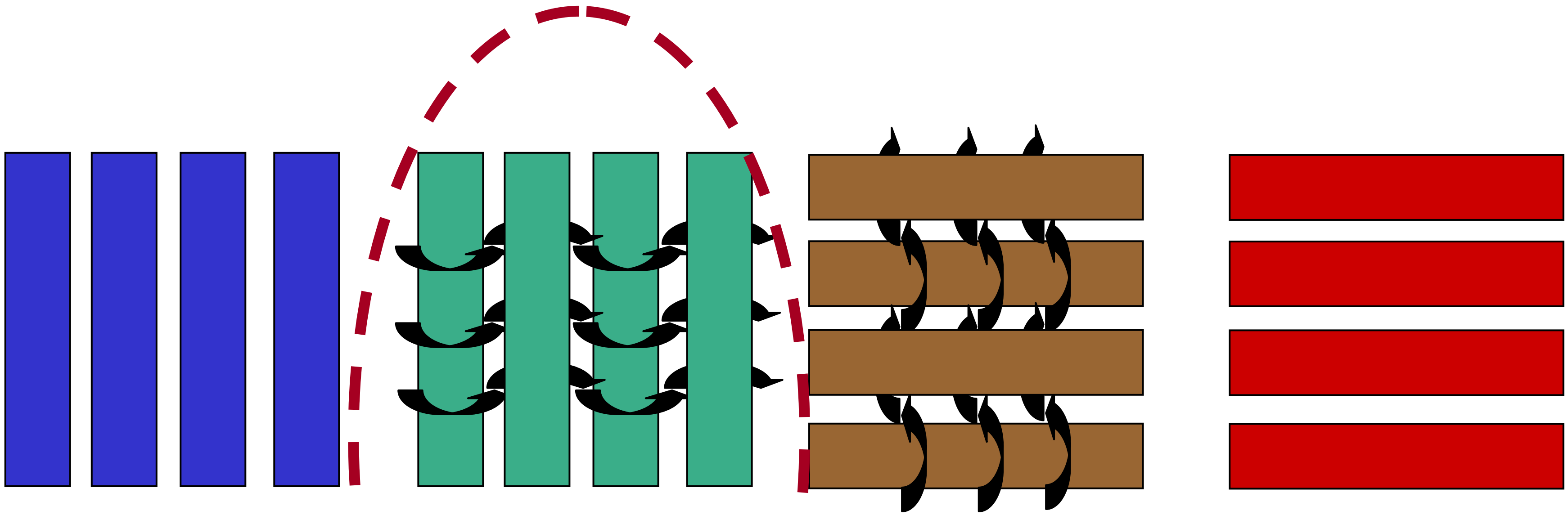
Explain the rationale for an integrated curriculum

Plan ways to benchmark an existing curriculum

Describe the process for designing and implementing an integrated curriculum

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

ENGINEERING SKILLS

- **Call them engineering skills - not ”soft skills”**

  Communicating and working in teams are ways to express and apply technical knowledge. Therefore, technical communication skills, teamwork, problem solving, professional ethics, etc. are **engineering skills**

- **Provide opportunities to develop skills - not to “add 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 the underlying psychological and social principles of these skills.

- **Integrate learning - do not “append” skills modules**

  Practicing personal, interpersonal, product, process, and system building skills is the way to apply and express technical knowledge. Engineering skills are learned in the technical context.

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 same kind of list could be made for teamwork, problem solving, professional ethics, and other engineering skills.

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

WHY INTEGRATE KNOWLEDGE AND SKILLS?

cdio

Pedagogical Reasons

The nature of personal and interpersonal skills depends on the context in which they are taught and assessed

Students working knowledge of engineering fundamentals is reinforced through the practise of engineering skills

Faculty serve as role models when they demonstrate their commitment to engineering skills and their own competence in skill areas

Practical Reasons

We make dual use of available time and resources

We capitalize on the synergy of the simultaneous learning of engineering skills and disciplinary knowledge

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)

BEST PRACTICE

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

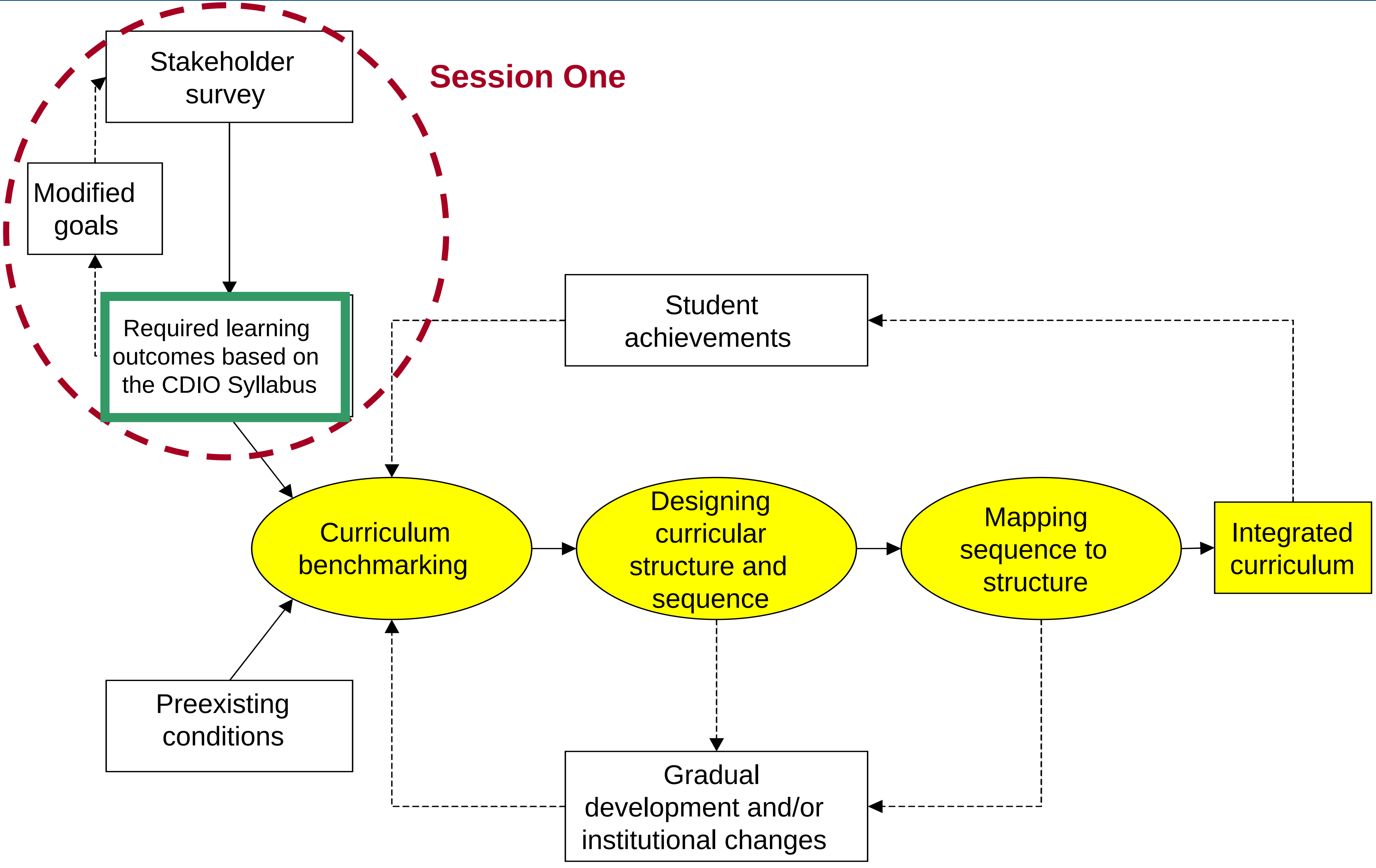
(See Handbook, p. 10)

ACTIVITY: ENGINEERING SKILLS

How are students' engineering skills developed through your program?

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

DESIGNING AN INTEGRATED CURRICULUM



CURRICULUM BENCHMARKING

Benchmarking means marking a known position for later reference and comparison. These comparisons can be made across time or across groups at one or more points in time. They may be internal or external to the program.

- 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

BENCHMARKING METHODS

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

SAMPLE BENCHMARKING 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

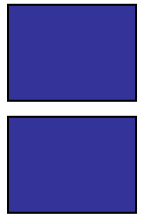
1. Change the course structure?

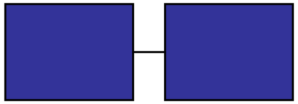
2. Retask existing courses?

3. Create new courses?

SAMPLE STRUCTURES

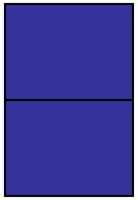
Conventional

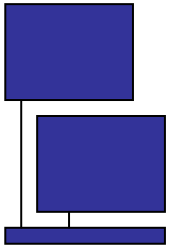




Sequential

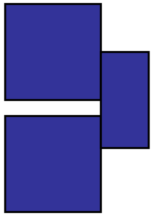
Block

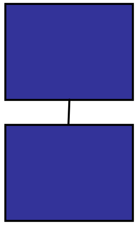




Bus or Backbone

Linked/merged





Simultaneous

SEQUENCING THE CURRICULUM

THE BLACK-BOX EXERCISE

INPUT:
Previous knowledge and skills

→

Course

(black box)

→

OUTPUT:
”Final” learning outcomes, competence for the engineer

Input to following courses

All courses or modules in the program are presented through their input and output only

- Enables efficient discussions
- Makes connections visible (as well as lack thereof)
- Serves as a basis for improving coordination between courses

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 ENGINEERING SKILLS

INTEGRATION OF SKILLS				
Year 1	Introductory course	Physics	Mathematics I	
	Mechanics I	Mathematics II	Numerical Methods	
Year 2	Mechanics II	Solid Mechanics	Product development	
	Thermodynamics	Mathematics III	Fluid mechanics	Sound and Vibrations
Year 3	Control Theory	Electrical Eng.	Statistics	Signal analysis
	Oral communication	Written communication	Project management	Teamwork

(Schematic, based on the curriculum in Vehicular Engineering at KTH)

MAPPING CDIO LEARNING OUTCOMES ONTO THE CURRICULUM

Find appropriate combinations of disciplinary knowledge, engineering skills, and attitudes

- Sequence the CDIO knowledge, skills, and attitudes from simple to complex
- Build on strengths:
  - Identify the CDIO learning outcomes already taught in existing courses and consolidate these if necessary
  - Identify faculty who are enthusiastic about developing their courses in this direction and work with them
- Create new courses when necessary
- Take advantage of the course's sequence in the program
- Facilitate coordination between courses (communication between faculty)

INTEGRATED CURRICULUM - 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)

ACTIVITY: AGREE OR DISAGREE?

SD = Strongly Disagree; **D** = Disagree; **N** = Neither disagree nor agree; **A** = Agree; **SA** = Strongly Agree

An integrated curriculum design process can be carried out in many different ways.

Program leader support and resources are desirable, but not required.

Support and commitment for the change process are needed from all stakeholder groups.

Active student participation in all phases fosters creative ideas and facilitates implementation.

Monitoring of programs and achievements needs to be regular and consistent.