Ready to Engineer

Conceive **D**esign **I**mplement **O**perate

THE CDIO INITIATIVE

- **The CDIO Initiative is an international initiative for the reform of engineering education**

- **It develops an approach to engineering education that uses the product/system/process lifecycle as the context of the education**

- **Founded in 2001 by MIT, Chalmers, KTH and Linköping University. Currently over 50 universities collaborate in the initiative**

CDIO DISSEMINATION

ORIGINAL COLLABORATORS

Chalmers

KTH

Linköping

MIT

EUROPE

N. AMERICA

REST OF WORLD

COLLABORATORS

Denmark Tech. U.

Queen's U., Belfast

US Naval Academy

U. Auckland

U. Pretoria

U. Liverpool

École Poly., Montréal

Queen's U. Ontario

Singapore Poly.

Hogeschool Gent

....

CENTRAL QUESTIONS FOR ENGINEERING EDUCATION

- **What is the full set of knowledge, skills and attitudes that a student should possess as they graduate from university? At what level of proficiency?**
  - ***In addition to the traditional engineering disciplinary knowledge***
- **How can we do better at assuring that students learn these skills?**
  - ***Within the available student and faculty time, funding and other resources***

WHAT DO ENGINEERS DO?

”Scientists investigate that which already is.
Engineers create that which has never been.
- Theodore von Karmann

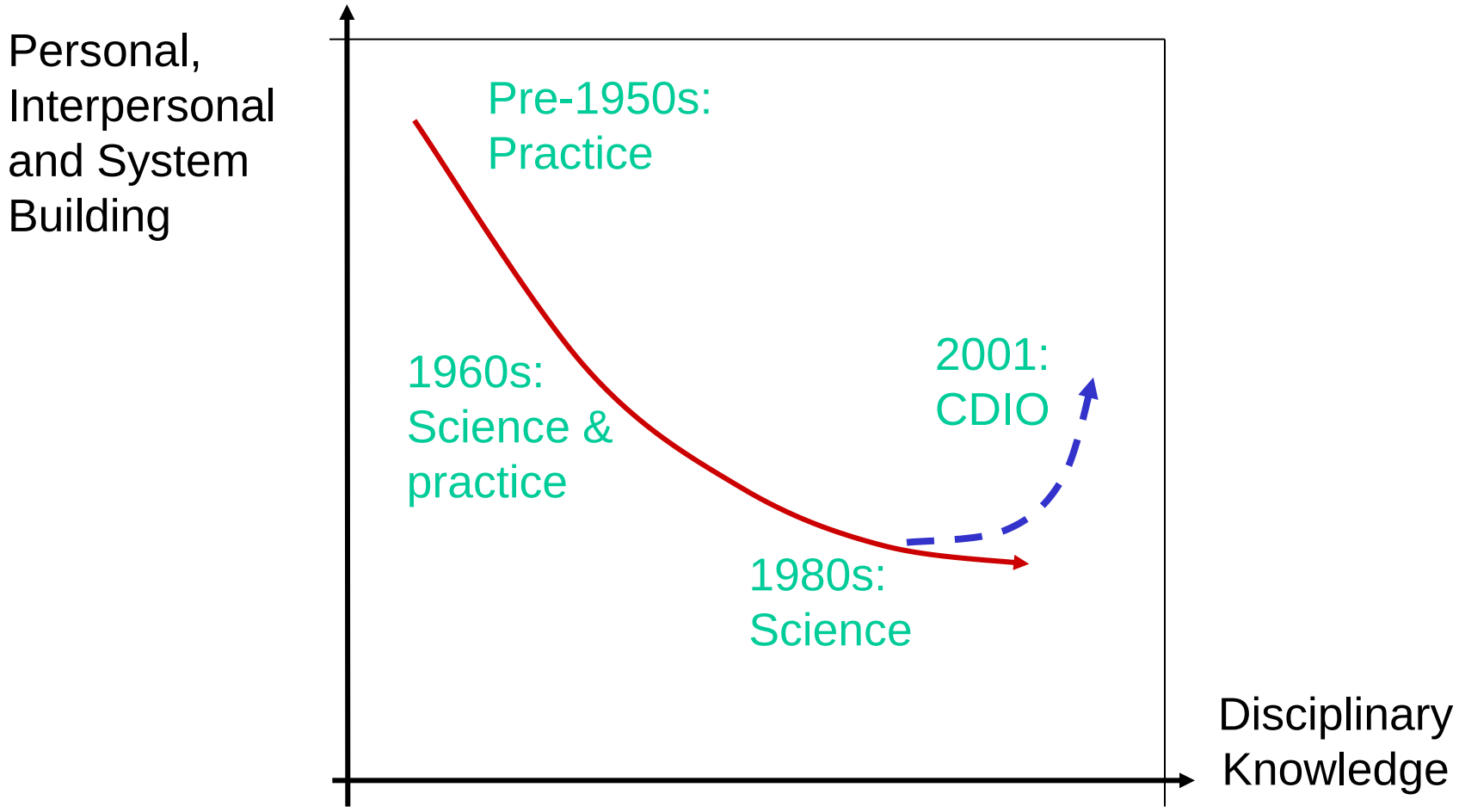
”What you need to invent, is an
imagination and a pile of junk”
- Thomas Edison

”What is chiefly needed is skill
rather than machinery”
- Wilbur Wright

”Engineers Conceive, Design, Implement and Operate complex products and systems in a team-based environment”

We have adopted CDIO as the engineering context of our education

EVOLUTION OF ENGINEERING EDUCATION



Engineers need *both* dimensions, and we need to develop education that delivers both

GOALS OF CDIO

- To educate students to master a ***deeper working knowledge*** of the technical fundamentals
- To educate engineers to ***lead in the creation and operation*** of new products and systems
- To educate future researchers to understand the importance and ***strategic value of their work***

CENTRAL QUESTION #1

What is the full set of knowledge, skills and attitudes that a student should possess as they graduate from university?

- ***At what level of proficiency?***

- ***In addition to the traditional engineering disciplinary knowledge***

THE NEED

Desired Attributes of an Engineering Graduate

- **Understanding of fundamentals**
- **Understanding of design and manufacturing process**
- **Possess a multi-disciplinary system perspective**
- **Good communication skills**
- **High ethical standards, etc**

Underlying Need

Educate students who:

- **Understand how to conceive-design-implement-operate**
- **Complex value-added engineering systems**
- **In a modern team-based engineering environment**

WHAT IS THE SET OF KNOWLEDGE, SKILLS AND ATTITUDES?

- **Technical Knowledge & Reasoning**
  - Knowledge of underlying sciences
  - Core engineering fundamental knowledge
  - Advanced engineering fundamental knowledge

- **Personal and Professional Skills & Attributes**
  - Engineering reasoning and problem solving
  - Experimentation and knowledge discovery
  - System thinking
  - Personal skills and attributes
  - Professional skills and attributes

- **Interpersonal Skills: Teamwork & Communication**
  - Multi-disciplinary teamwork
  - Communications
  - Communication in a foreign language

- **Conceiving, Designing, Implementing & Operating Systems in the Enterprise & Societal Context**
  - External and societal context
  - Enterprise and business context
  - Conceiving and engineering systems
  - Designing
  - Implementing
  - Operating

CDIO Syllabus contains 2-3 more layers of detail

BASIC RELATIONSHIPS

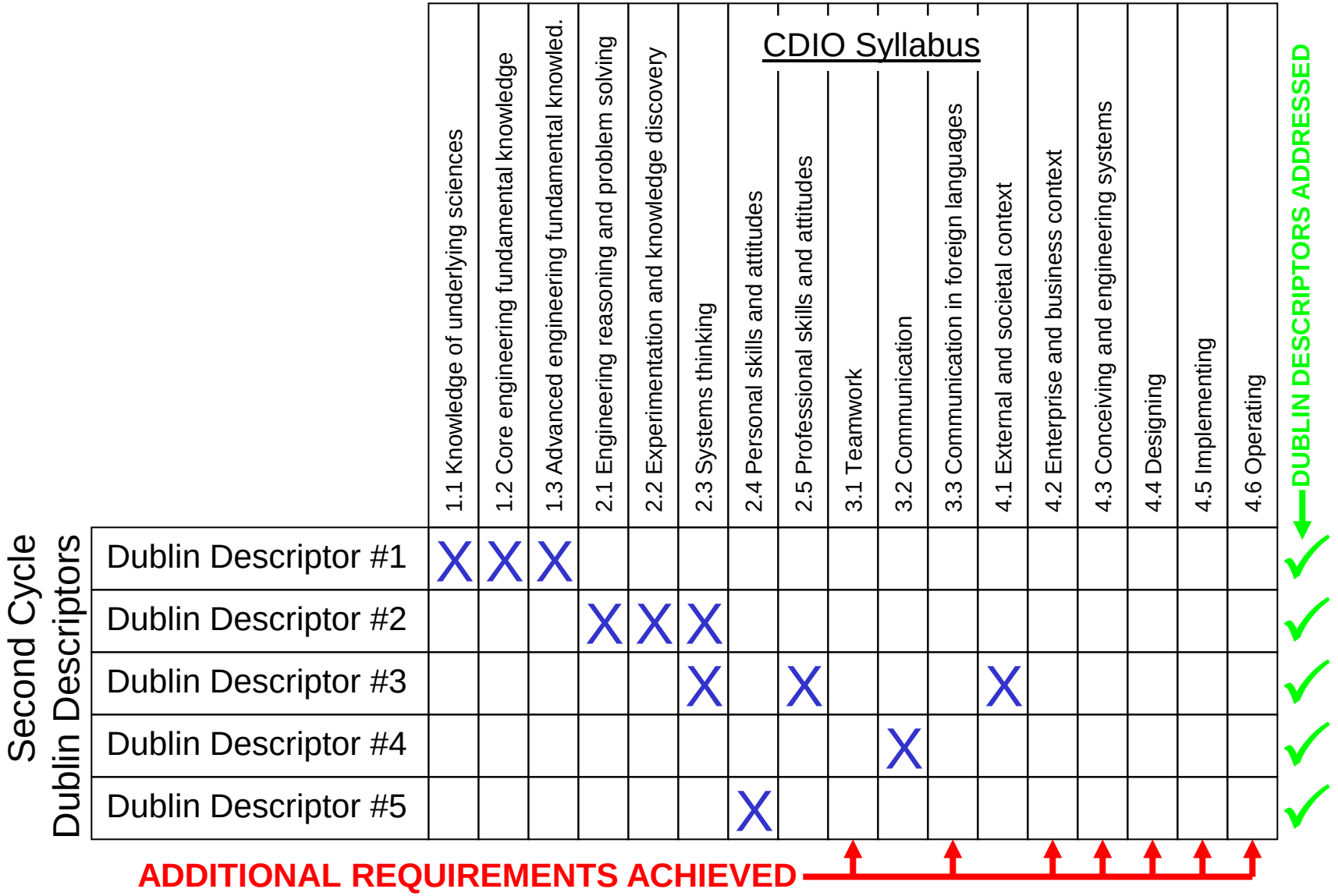
Dublin Descriptors

- General and not connected to any profession
- 5 program-level goals
- Difficult to connect to course goals
- Minimum proficiency level requirements

CDIO Syllabus Goals

- Connected to professional context, subject area and local profile
- > 17 program-level goals
- Includes more detailed and specific course goals
- Proficiency levels may be set to exceed minimum requirements

DUBLIN DESCRIPTORS X CDIO



EUR-ACE / ASSIN X CDIO

Relation between CDIO Syllabus - EUR-ACE / ASIIN Standards				EUR-ACE ASIIN					
CDIO Syllabus				1	2	3	4	5	6
1	Technical knowledge and reasoning	1.1	Knowledge of underlying sciences	1					
		1.2	Core engineering fundamental knowledge	1					
		1.3	Advanced engineering fundamental knowledge	1					
2	Personal and professional skills and attributes	2.1	Engineering reasoning and problem solving		1	1			
		2.2	Experimentation and knowledge discovery		1	1	1		
		2.3	System thinking		1	1	1	1	
		2.4	Personal skills and attitudes		1	1	1	1	1
		2.5	Professional skills and attitudes				1	1	1
3	Interpersonal skills: Teamwork and communication	3.1	Teamwork						1
		3.2	Communications						1
		3.3	Communications in foreign languages						1
4	Conceiving, Designing, Implementing and Operating systems in the enterprise and societal context	4.1	External and societal context				1	1	1
		4.2	Enterprise and business context				1	1	1
		4.3	Conceiving and engineering systems				1		
		4.4	Designing				1		
		4.5	Implementing				1	1	
		4.6	Operating				1	1	

CENTRAL QUESTION #2

How can we do better at assuring that students learn these skills?

– ***Within the available student and faculty time, funding and other resources***

ACTIVE AND EXPERIENTIAL LEARNING

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:

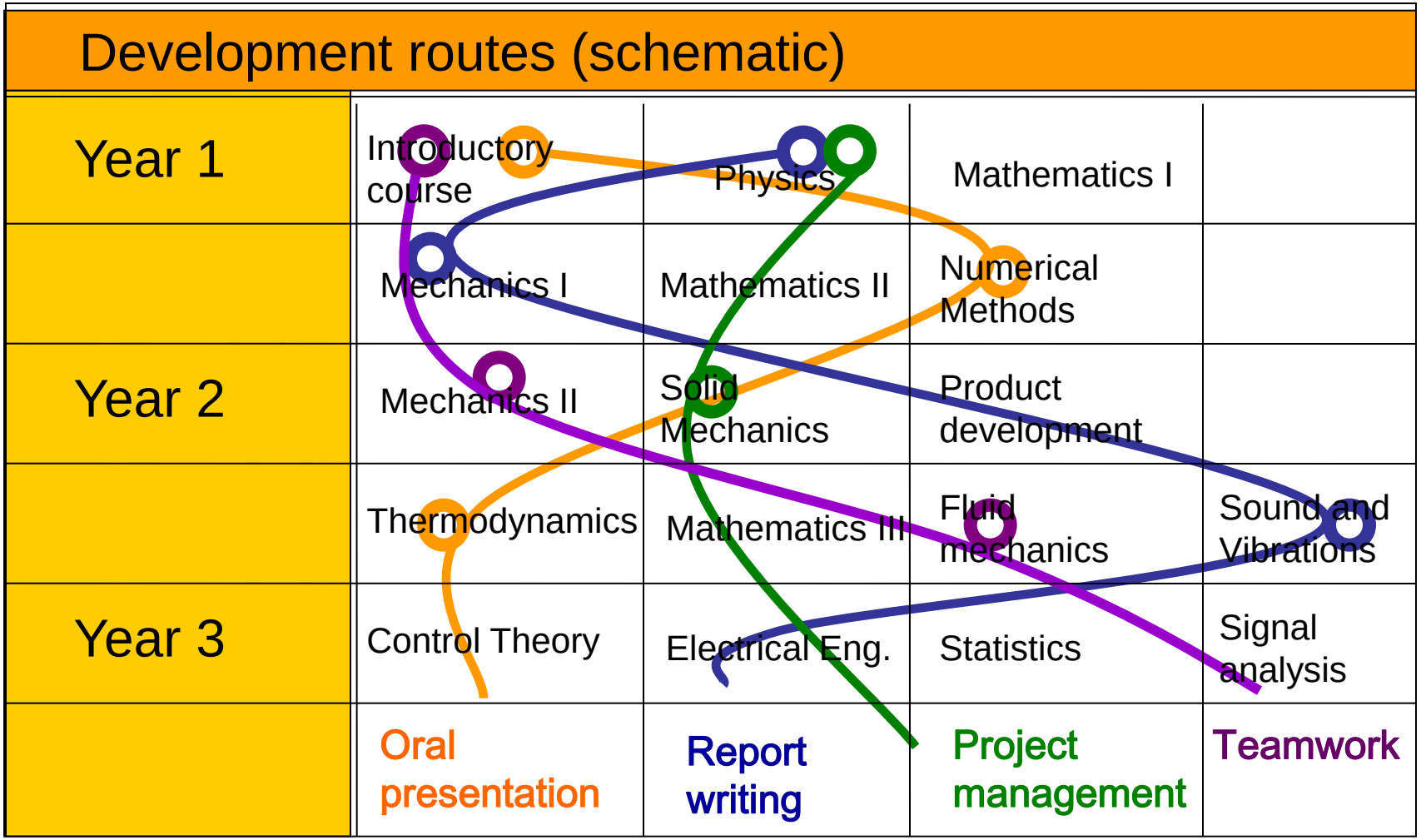
Design-implement experiences

Problem-based learning

Simulations

Case studies

CONNECTING IT ALL IN AN INTEGRATED CURRICULUM



Implementing the change

- How can we work systematically to improve our educational programs?

THE CHALLENGE - TRANSFORM THE CULTURE

CURRENT

- **Engineering Science**
- **R&D Context**
- **Reductionist**
- **Individual**

DESIRED

- **Engineering**
- **Product Context**
- **Integrative**
- **Team**

... but still based on a rigorous treatment of engineering fundamentals

IMPLEMENTING CHANGE AT UNIVERSITIES

Observation #1: **Universities are, by design, resistant to change as organizations**

Observation #2: **Notwithstanding Observation #1, universities *can* be changed by appropriate application of best practice in leading organizational change**

EXAMPLES:
EARLY SUCCESSES

- **Start, or modify, a first-year engineering course that includes a simple design-implement experience.**
- **Modify an upper-level course to include a simple, low-cost design-implement experience.**
- **Modify an appropriate meeting room or flexible classroom space to create a design-implement workspace that supports hands-on and social learning.**

TO LEARN MORE ABOUT CDIO

- **Visit www.cdio.org**

- **Read the book: *Rethinking Engineering Education: The CDIO Approach*, Crawley et al., Springer-Verlag, ISBN 0387382879**