SUSTAINING MOMENTUM WHEN IMPLEMENTING CDIO IN A SET OF STUDY PROGRAMS

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SUMMARY

At the Technical University of Denmark, CDIO has been implemented in seven programs covering Mechanical, Chemical and Biochemical, Civil, Architectural, Electrical, IT, and Traffic Engineering.

After the initial decision and launch of CDIO at the Technical University of Denmark, the challenge is: How can momentum be sustained in the organization so that all involved parties keep a continuous focus on CDIO implementation, evaluation of results, and adjustments to and further development of study plans and courses? What factors may contribute to this continuous process, and what challenges should be taken into consideration?

After some background information about the scope and the initial process of the CDIO implementation at DTU, the questions addressed by this paper are presented.
An overview of organization, roles and responsibilities – in general and specifically related to the CDIO process – is provided as background information for the subsequent analysis of the factors that challenge and contribute, respectively, to a successful CDIO implementation process.
Specific measures to sustain momentum are then presented. They include measures taken at different levels from department to international level. Two specific study programs are used to illustrate challenges and experiences in the continuous CDIO implementation process.
Finally, conclusions and perspectives for future measures are discussed.

Background

The Technical University of Denmark is in the process of implementing the CDIO principles in all Bachelor of Engineering programs. The Bachelor of Engineering (B ENG) is a 3½-year program which qualifies the students to take on jobs within the industry, e.g. in production units, project management or control and support functions. CDIO has been implemented in seven programs covering Mechanical, Chemical and Biochemical, Civil, Architectural, Electrical, IT and Traffic Engineering.

The implementation process was initiated in 2008 with the first year courses, and by 2011 all bachelor of engineering programs will be CDIO based.

The introduction of the CDIO philosophy to the Bachelor of Engineering (B Eng) programs at DTU serves the obvious purpose of improving the quality of the engineering education. More specifically we see the combination of CDIO and a faculty of research-active professors as a

way to maintain what has always been the hallmark of B Eng studies at DTU: emphasis on applied engineering as well as an up-to-date and a high level of professionalism.

The implementation process was headed by a committee led by the Dean of Education which included representatives among students, teachers, program coordinators, and the study administration. The committee concluded its work in 2008 and established guidelines for DTU´s adaption to CDIO, and it produced a detailed plan of action [1] that defined common goals and guidelines for the future CDIO-based study programs. In accordance with this plan, the program coordinators of the individual B Eng programs have revised the study programs together with supporting working groups of teachers and students.

Questions to be addressed

After the initial decision and launch of CDIO during the first year of study the challenge is: How can momentum be sustained in the organization so that all involved parties keep continuous focus on CDIO implementation, evaluation of results and adjustments and further development of study plans and courses? What factors may contribute to this continuous process, and what challenges should be taken into consideration?

A successful CDIO implementation is about changing not only behavior but also mind-setting and priorities for a vast number of people throughout the university. This requires deliberate use of change management processes at different levels. The various processes and measures must all be directed towards the same goal as well as being based on the same values and ideas.

## DTU organization, roles, and responsibilities

An overview of the organizational structure and parties involved in the CDIO process serves as background for the subsequent analysis of factors that challenge and contribute, respectively, to a successful CDIO implementation process. Table 1 gives an overview of parties with a significant role in the CDIO implementation process at DTU. An asterisk (*) marks the organizational entities which have been established as part of the CDIO implementation process.

	Formal role	**Specific responsibilities in relation to the CDIO implementation process**
Dean of Undergraduate Studies	Member of the University Executive Board. Appoints coordinators for the individual study programs. Chairs regular meetings with all program coordinators and regular meetings with the heads of Department Study Boards.	Responsible for a successful implementation of CDIO at DTU's B Eng programs in accordance with to the development contract between DTU and the Ministry. Initiates miscellaneous initiatives across DTU.
Department Study Board	Responsible for the courses supplied by the DTU department. One study board for each of DTU's nineteen departments.	
Program coordinator	Responsible to the Dean for the content and quality of the study program. Undertakes the practical organization of teaching and assessment in co-operation with the study board.	Responsible for the establishment of relevant teacher teams. Responsible for ensuring that • all CDIO syllabus goals are covered by the study plan in a coherent and progressive structure

		• all teachers know how their courses contribute to the goals • well-functioning teacher teams and a general culture of learning are developed
Study plan committee *)		Supports the program coordinator. Consists of study program coordinator (chair), and teacher and student representatives.
Teacher teams *)		Responsible for ensuring coordination and progression across the education program
LearningLab DTU	Development of faculty's teaching skills in general	Development of faculty's CDIO skills

Table 1. Parties with a significant role in the CDIO implementation process at DTU.
*) = Organizational entities established as part of the CDIO implementation process.

Figure 1 illustrates the relation between departments that are responsible for the supply and quality of the courses and the study programs. The study programs are headed by program coordinators.
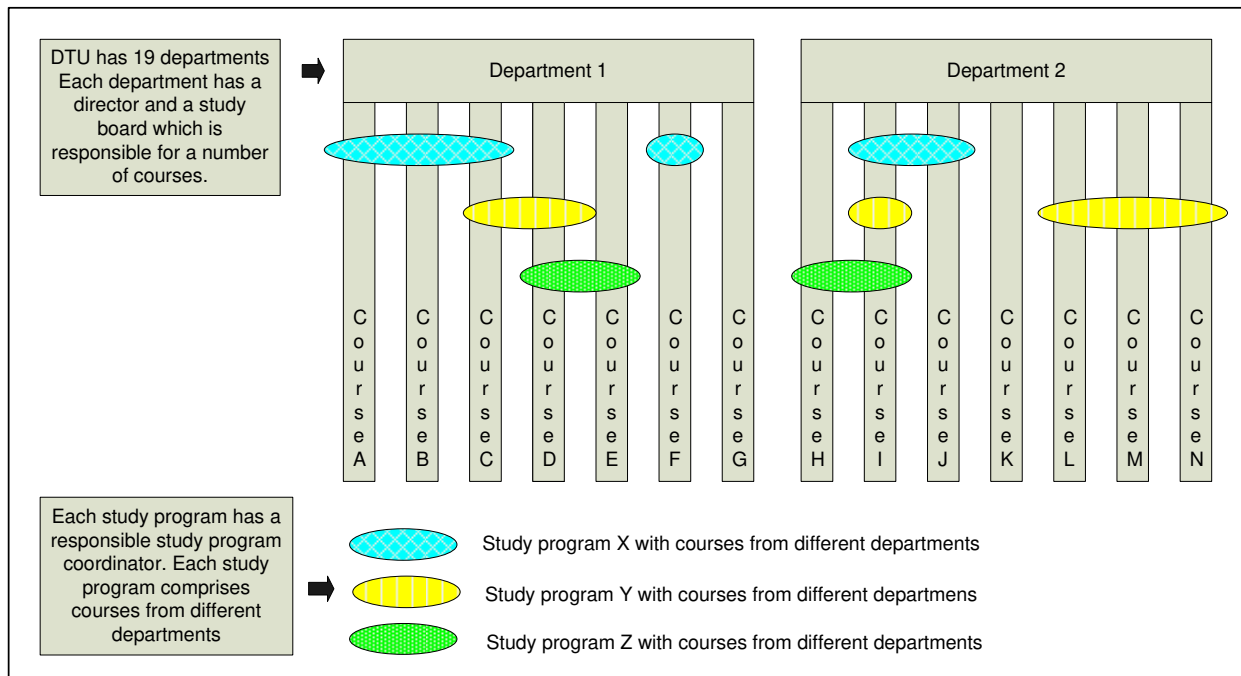
Figure 1. An overview of the relation between departments, courses, and study programs.

Factors in the DTU organization and culture that challenges a successful CDIO implementation process
A number of factors at institutional and individual level constitute challenges that have an impact on the CDIO process:

• A tradition of the teachers having individual freedom of choice of teaching methods.

- A tradition of regarding teaching as an individual, 'private' activity – and therefore a limited tradition of cooperation on teaching.

- A relatively recent (dates approximately ten years back) introduction of top-down management systems at DTU – and therefore only limited experience with centrally initiated change management processes.

- At tendency in all parts of the university system – as is the case in the academic world in general [2] – to give research activities and results a higher priority and more credit than teaching and educational activities and results.

- The study program coordinators do not have a formal managerial role and they do not have their own budget for the study program. They do not have the decision-making authority to "hire and fire" teachers, to allocate teachers to courses, or to allocate budgets to the courses.

- Most study programs comprise courses from several departments and several study boards are involved in each program (figure 1). This gives the program coordinators the challenge of coordinating courses across several departments with separate lines of management. It is a complicated task for the program coordinator to get and maintain an overview of all courses in the program, and it is difficult for him/her to see to it that teachers from other departments act on decisions and needs for course development.

Several of these factors leave the program coordinators with "management by a smile" as their primary tool. They have to focus on cooperation in a good spirit and create motivation and goodwill.

Factors in the DTU organization and culture that contribute to a successful CDIO implementation process
One the other hand, a number of factors that contribute to the CDIO process can be identified:

- The Dean of Undergraduate Studies is personally very engaged in the implementation of CDIO at the university, and he has been actively involved from the introduction of general CDIO implementation at DTU B Eng programs. He therefore has a profound knowledge of CDIO and is also active in the international CDIO collaboration.
He is responsible for a successful implementation of CDIO at DTU's B Eng programs according to the development contract between DTU and the relevant ministry, which gives him special obligations to ensure the progress of the CDIO process.

- The monthly meetings between the Dean and all program coordinators have been turned into a forum for developing the CDIO principles and the way they are implemented at DTU, and for deciding what new measures should be taken. The meetings also constitute a frame for experience sharing and discussion of challenges related to the study programs and the CDIO implementation. These meetings have taken over the function as "steering committee" for CDIO at DTU that was placed in a special committee in the initial phase of the CDIO process. Thus, the central management of the CDIO implementation process has been moved from a "project group" and merged into the regular organizational structure to ensure a continuous focus.

- From the offset of the CDIO process, the Dean provided each study program with an amount of money to support the launch of new CDIO based courses. This funding has been used to buy equipment for student projects, to employ external teachers with special skills in project management, for staff to participate in international CDIO conferences etc.

Incentives
- DTU has a special career path which acknowledges special efforts and achievements related to teaching and education.
- CDIO offers an opportunity for teachers to specialize in - and fill special roles related to – teaching and education. This may be particularly relevant for teachers who do not have an extensive research profile

Individual motivation
- DTU teachers with a background in the engineering college The Danish Engineering Academy (DIA) – that was merged with DTU in the 90s – have a tradition of close cooperation with colleagues on teaching matters.
- The presence of "fireballs" among the program coordinators and other teachers who are willing to make an effort – and to inspire colleagues to make an effort – to actualize the potentials of the CDIO principles.

Individual capabilities
- DTU has a well-established and comprehensive training program for new faculty members which provides them with a conceptual framework, methods, and tools to develop their teaching methods [3].

Measures taken to sustain momentum
One of the lessons learned from the initial phases of the CDIO implementation process was that the standard organizational structures are not sufficient to ensure an on-going and successful process. Meetings and decisions involving only a few key-players (like Dean and program coordinator) will not in itself have the necessary impact on the teachers' motivation for contributing to the process of coordination and modifications of their courses according to the CDIO principles. Likewise, standard courses introducing the teachers to CDIO do not give them a sufficient basis for working with the actual implementation in the individual courses.

More and different kinds of activities are needed! At DTU the answer has been to introduce and run a number of activities at different levels in the organization.

Goal: Development of a Learning Oriented Culture
A general goal "to develop a general learning oriented culture among the teachers" has been formulated as part of the development of a CDIO Handbook [4] directed to program coordinators, study plan committees and all involved teachers. Within such a culture, teaching is regarded as a joint affair where teachers continually exchange experiences, share considerations and advice, and involve colleagues in the development of courses and teaching. Thus, teachers are participants in learning communities with a strong focus on how to develop courses and study programs to improve student learning, and also with a focus on continuous development of the teaching and CDIO skills of faculty members (ref. CDIO standard 9 + 10).

Means
Different measures have been taken to address the obstacles to the development of learning communities to support the CDIO process – including resource issues, teachers' skills, and factors that affect faculty motivation. The measures include:

At department and program level (additional to program coordinator, study plan committee, and department study board):
- Establishment of teacher teams:
  In order to ensure an appropriate progression and coordination of individual courses, it is essential that well functioning teachers teams are established. The teams must meet regularly and discuss the content of individual courses, cross-disciplinary projects, teaching methods, timing and types of evaluation etc. Different fora are relevant for different purposes:
  - Subject-oriented working groups consisting of teachers teaching the same subject area. The groups serve to ensure coherence and progression within specific subject areas – and to avoid overlap between courses.
  - Semester teams consisting of teachers teaching courses during the same semester. These teams meet at least twice each semester. The program coordinator meets with the chairpersons from these teams in the end of each semester to discuss possible overall changes of the study plans.
- Ad hoc courses and workshops (especially for new study programs). An example is the new study program B Eng in Food Analysis at DTU which was developed during the spring of 2010. A series of workshops were held with teachers, student representatives, program coordinator and support from LearningLab DTU, and they included systematic discussions of qualifications required and the structure of the study program.

At cross-departmental level:
- Lunch meetings (with practical support from the DTU study administration). Approximately once a month, a teacher or a couple of teachers share their experiences from teaching at a CDIO based study program with other interested teachers during the lunch break. Typically an oral presentation lasting 20-30 minutes is followed by questions and discussions. Everyone who is interested is welcome to show up with their lunch and eat during the presentation.

At central DTU level (additional to meetings between dean and program coordinators):
- Biannual seminars lasting about half a working day for program coordinators and all interested teachers. An example is a seminar in December 2009 where external experts presented their views on how to teach and evaluate personal and interpersonal skills (ref. CDIO Syllabus section 2 and 3 [5]). About 60 teachers gathered and drew valuable inspiration for their future work.
- A CDIO Handbook with detailed explanations of what CDIO is all about and how it can be implemented in the courses combined with some tools of support and instructions for teachers and program coordinators [6].
- Teacher training: CDIO introduction is embedded in the general education program for new faculty members.

At international level
- Participation in regional CDIO meetings and the annual CDIO conferences. The Dean makes an effort to urge faculty members to contribute to and participate.

- Participation in inter-Nordic benchmarking of corresponding study programs. During 2009-2011 DTU is working on a benchmarking project funded by the EU *Nordplus* program. The title of the project is "QA in HEI" and the outcome is intended to be a well functioning model for quality assurance of CDIO at the higher educational institutions.
- Hosting the 2011 CDIO conference is expected to further develop the interest, motivation, and competencies to enhance the CDIO implementation process across DTU.

Two cases from DTU

Two specific study programs illustrate some of the challenges and experiences at DTU. The study programs are B Eng in Civil Engineering and B Eng in Architectural Engineering, both rooted in the Civil Engineering department.

The Civil Engineering ("C.E.") program is one of the "old" study programs at DTU that existed long before CDIO was introduced whereas the Architectural Engineering ("A.E.") is a relatively new study program designed according to principles that are much closer to the CDIO principles. The two programs each have their own program coordinator, and a number of teachers are involved in both programs.

The challenges of implementing CDIO in the two programs differ somewhat. Being a relatively new program, it has been easier in A.E. to establish coherence across a number of courses taking place in the same semester by combining them in a joint cross-course project (one per semester). The C.E. includes one CDIO project or course per semester. In two semesters, an existing course was changed in order to include an interdisciplinary project or a design build project with relations to other courses during the same semester, but without direct integration of courses. In two other semesters, a new course was established hosting either an interdisciplinary project or a design build project. In order to do that, one of the former courses was moved from the mandatory part of the program to the elective part, and another course was closed. The most important parts of the closed course were included in later courses leading to some changes in several courses later on.

In A.E., the start of the CDIO implementation in 2008 worked as a vehicle for the establishment of cooperation among the teachers. A well-functioning study program committee including teacher and student representatives was formed to make the overall planning. Due to the special funding in the initial phase, it has been possible for the program coordinator to organize joint activities for the teachers at the program (e.g. an excursion to a relevant exhibition) which has contributed to building up a team spirit. So far, the revised study program has been a success, and the teachers and program coordinator enjoy the acknowledgement they receive through the student feedback.

In C.E. teacher teams are still in the process of being established. It is a positive experience for the involved parties; the teachers are favourably disposed towards the fact that their work and teaching is subject to genuine interest for program coordinator and colleagues.

For both programs, the program coordinators have experienced that the establishment of semester teams is facilitated if they participate themselves in the start – with the positive side-effect that they get valuable information about the courses at each semester that will help them in the on-going coordination of the whole education program. The semester teams each have a chairman that – when the program coordinator is no longer participating in the team meetings – meet with the coordinator a couple of times per year.

What seems to be particularly motivating for the teacher team is to cooperate on an overall subject for all the courses on a semester - like energy design (A.E.) and flooding (C.E.). The teachers can draw on and learn from each other's different knowledge so that not only teaching methodology but also subject-oriented matters are discussed and developed.

However, there are also challenges! It has proved difficult to make all teachers realize that cooperation is mandatory – especially when the teachers belong to a number of different departments. As the program coordinator does not have any direct means of making the teachers attend meetings, the program coordinator has to accept that a few teachers might not be as involved as they should be – yet.

Concurrently with the CDIO implementation process, new initiatives have been taken at the Civil Engineering department. All teachers have been invited to a teaching seminar as a framework for discussion of principles of good teaching and learning. The seminar was a success, with good attendance, and engaged and qualified discussions. Such seminars contribute to development of a learning-oriented culture at the department. The intention is to organize teaching seminars every 12-18 months.

Key players in the CDIO implementation (program coordinators and teachers) at the two study programs have also participated in national as well as international seminars and conferences at DTU level.

Conclusions and Perspectives
At DTU a number of factors in the existing organization and culture pose difficulties for efforts to develop and improve education programs and teaching methodology in a coordinated way involving all teachers. We believe that this is situation is familiar to the vast majority of universities.

On the other hand, the experiences at DTU so far indicate that CDIO is very well suited as a platform for initiating activities that meet the challenges. Changing the culture - from perceiving teaching as a private, individualized task to regarding education and teaching as a joint effort that necessarily involves a lot of coordination and cooperation between teachers - does not happen overnight. However, changing the culture seems to be possible by using the very structured framework provided by CDIO as an off-set, and supplementing with organizational entities and processes both at a central and at a local, department level.

To sustain momentum, the motivation of the key players like program coordinators as well as the teachers needs to be maintained in an ongoing process. Therefore, future measures should include new ways of acknowledging and thus motivating the involved parties.

Possible future measures

Incentives
- Professionalization of the program coordinator role, including training and substantial financial compensation, to increase the status of this role and make it more attractive from a career-oriented perspective.
- Acknowledgement of the efforts of program coordinators and teachers making a special effort. This should be made very visible in the organization by clearly emphasizing individual cases as good examples. Acknowledgement of team performance is especially relevant in

Financial support
Financial support will make it possible for the program coordinators to organize joint activities for the teacher teams – to make it more attractive for them to cooperate and participate. Examples of activities are study tours and residential seminars, and invite external speakers to meetings. Such activities support the establishment of a team-spirit which is an important part of building a learning community among the teachers.

Evaluation
Evaluation of courses and study programs is an important source of information for ongoing adjustments of the education programs. Course evaluations have been part of the general procedures at DTU for a long time and, more recently, the need for evaluation of full study programs has been recognized. DTU has obtained very good results from peer evaluations of BSc Eng [7] and MSc programs across DTU and internationally. As mentioned previously, DTU is now a part of the international Nordplus project "QA in HEI" in which the DTU model that includes peer evaluations is used in the development of an internationally applicable model for quality assurance of CDIO in institutions of higher education. If the Nordplus model is functioning well as a tool for quality assurance, it will be applied on the rest of the B Eng programs at DTU at a later stage. The model also involves students actively in evaluation of study programs as student representatives are to participate in evaluation boards.

In a longer-term perspective, data from surveys with graduates and employers could be included in evaluation of study programs.

References

[1] CDIO på DTU's diplomingeniøruddannelser – Handlingsplan 2007-2008. (*CDIO at DTU's B Eng study programs – Action Plan 2007-2008).* DTU 2007. Avaible on http://www.dtu.dk/Nyheder/Publikationer.aspx?guid=%7BFF74A62A-F1CD-45E9-B956-1BFDA90E8FAE%7D.

[2] Boyer, Ernest L., Scholarship Reconsidered, Priorities of the Professorate. Princeton, New Jersey 1990.
John Bowden and Ference Marton, The University of Learning. Routledge, Oxon 2004.

[3] See the description of DTU's teacher training program at http://www.learninglab.dtu.dk/English/kurser/undervisere.aspx.

[4] Håndbog for CDIO på DTU's diplomingeniøruddannelser *(CDIO Handbook for B Eng programs at DTU)*, 2009. Available at http://www.dtu.dk/cdio.

[5] The CDIO Syllabus: http://www.cdio.org.

[6] Håndbog for CDIO på DTU's diplomingeniøruddannelser *(CDIO Handbook for B Eng programs at DTU)*, 2009.

[7] P. H. Andersson, P.M. Hussmann and H.E. Jensen, Doing the right things right – Quality enhancement in Higher Education. Sefi Annual Conference, Rotterdam 2009. Can be downloaded from: http://www.sefi.be/?page_id=1698

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