CDIO AS THE EDUCATIONAL AND CULTURAL STRUCTURING ELEMENT IN THE DTU B.ENG. IN ELECTRONICS PROGRAMME

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ABSTRACT

The aim of this paper is to describe how a CDIO based four semester study can be documented in such a way, that a homogeneous quality can be maintained over time. One purpose is to help new teachers to fully understand their role and obligations, not only in their particular course, but also as a part of the complex CDIO based education. The case used is the B.Eng. study in Electronics at the Technical University of Denmark (DTU)

Implementing CDIO calls for many changes in the way that we build and document an program, having implemented CDIO at the B.Eng. program in electronics, it has been found that the normal public and internal course documentation platforms are insufficient to keep the large amount of information needed to describe the program as a whole, and the large amount of interaction between the individual courses, a master document describing the program has been developed to cover the first 4 semesters in the program, this paper is meant as an inspiration to others that might find this method beneficial.

In todays modern and constantly changing society it must be expected that staff is constantly moving in and out between different research projects, while at the same time teaching courses at levels ranging from very advanced topics to introductory courses.
In most cases a course will be given by the same teacher every semester, but for some courses (often the introductory courses) teachers change frequently.
In this dynamic system the master document proposed helps in conveying crucial information from prior to new teachers, that otherwise could be lost in the teacher exchange process.

KEYWORDS

CDIO-based curriculum, Master document, Quality assurance, Learning objectives, Design-build projects, cross disciplinary projects, Soft skills implementation, Curriculum planning

INTRODUCTION

Today two different lines of engineering programmes exists in Denmark.

1- The Bachelor of Engineering programs (B.Eng.) and
2- The Bologna model based Bachelor of Science + Master of Science (BSc + MSc)

The Bachelor of Engineering program is focusing primarily on qualifying the students to professional engineering jobs

Whereas the Bachelor of Engineering programme is qualifying students primarily to continue their education on a Master of Science programme, with a clear aim towards a scientific career. The B.Eng. has strong bonds to industry, bonds that has been build and strengthened by the mandatory and combined industrial internship and bachelor thesis. The B.Eng. program in electronics was merged from the Danish Engineering Academy into DTU. It was from the start clear that teachers from the scientific side would gradually assume teaching responsibilities in the B.Eng. programme, the challenge at this point was: How can the B.Eng. culture with close linking between teacher-student-industry be conveyed to the new teachers?

-The B.Eng. programme has 4 mandatory semesters, internship in industry and few elective courses.

-The B.Sc. and M.Sc. programmes has many elective courses and no internship

Each of these engineering programmes have guided by competence profiles describing the competences obtained by the students. It is clear, that The B.Eng. programme is easily tailored to comply with the competence profile, because of the large mandatory contents, (in other words, highly controllable), whereas it is a challenge to assure that the B.Sc. and M.Sc. programmes comply with the competence profiles (difficult to control because of the large number of elective courses) .

DTU has in 2006 chosen the CDIO concept as the platform for developing the B.Eng. programmes [2], it will be shown in this paper, that the elements in the CDIO syllabus and the large demands of well structured documentation of the programme in fact helps to assure the preservation of the culture of the B.Eng. programme, simply because it is now documented during the CDIO implementation process. An example from Swedish universities on how the documentation and implementation work on a large number of educational programmes are carried out using integrated program descriptions are found in [11] and [12]. These papers by Malmqvist et. al. gives a very well structured approach, that can be used when designing new educational programmes and when generating the program plan and the course plans, which is the general method a university uses to describe its programmes to the students and the outside world. Program goals and program design matrices are used as tools to assure that program goals are fulfilled.

This paper is describing the implementation of CDIO in one engineering programme and focuses on how to assure and maintain the quality and culture of the education. In other words focus is directed towards the teachers, and the proposed master document is used to guide the teachers when they, as responsible for their course plan, maintain and teach the course. The next chapters describes first the course plan, showing the course inter dependency, the placement of cross disciplinary projects and later the master document is described with an example from a second semester course then the progression of the "soft skills" is described, discussed and proposals are given on how to assure progression in soft skills and teamwork, after that evaluation results from a course in the programme is presented followed by discussions and conclusion.

PROGRESSION OF TECHNICAL KNOWLEDGE AND REASONING

The B.Eng. program in electronics admits students both summer and winter. It has 3 progression levels on its first 4 semesters. The 1'st and 2'nd semester courses are offered both in the spring and fall semester, whereas all the remaining courses are scheduled once a year only. This is possible as there is no progression between the 3'rd and 4'th semester courses, the progression is strong from 1'st to 2'nd and from 2'nd to 3'rd and from 2'nd to 4'th semester.
From the 5'th semester the students have elective courses giving them the possibility to specialize in a field of interest, to aid the students in their selection of courses, recommended study plans for 4 different technical fields are offered, if the students prefer they can design their own individual plan, choosing from a list with more than 50 elective courses.
At the end there is 20 weeks industrial internship followed by a 10 week final project.

The DTU B.Eng. programme in electronics has 120 ECTS mandatory courses on the first 4 semesters, 30 ECTS elective courses on the 5'th semester, and 15 ECTS elective courses, on the 6'th and7'th semesters. On the 6'th and 7'th semester the programme contains 30 ECTS industrial internship followed by 15 ECTS B.Eng. final project. The final B.Eng. project follows the internship subject closely and is normally carried out in the same industrial company as the internship, only very few final B.Eng. projects are carried out on campus.

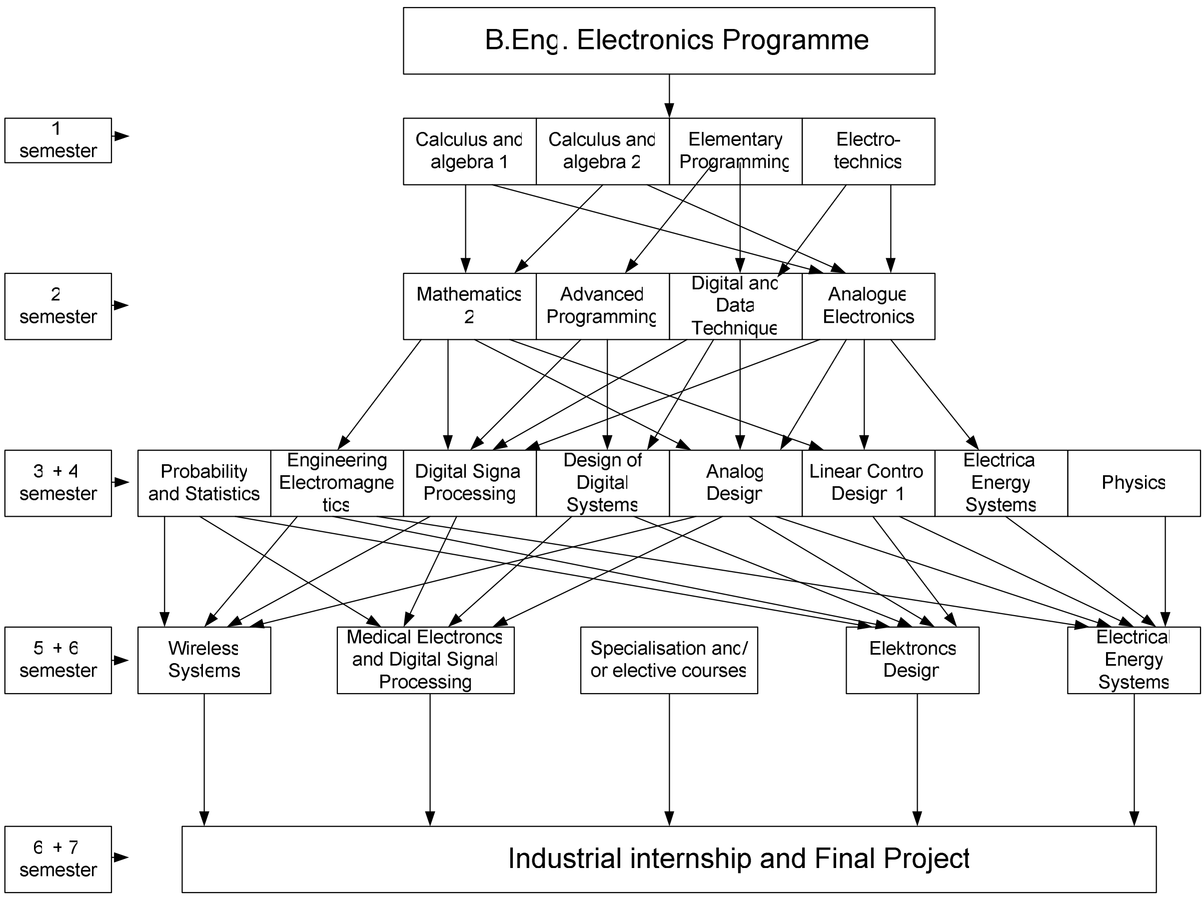

Figure 1, DTU B.Eng. programme in electronics, course progression in technical knowledge

Figure 1 depicts the course progression (from top to bottom) in the curriculum, the arrows pointing away from a particular course points towards courses that are next in the progression chain. The first four semesters are mandatory and taught using the CDIO standards. This allows that the courses are highly interlinked, both in Technical knowledge, the Personal and generic professional skills, the Social skills and in the Professional engineering skills as called for in CDIO Syllabus, the link is very strong between courses on the individual semesters and teacher teams on each semester supports this linkage by having regular meetings.

Another demand in the CDIO syllabus is the cross disciplinary projects [10] on each semester. It is therefore imperative that a teacher responsible for a cross disciplinary project understands that he must now perform in relation to a predefined educational culture as part of a large system, instead of exercising the "course owner" mindset that is often seen in free elective study programmes.

Having implemented CDIO in the program, the course catalogue contents have changed and the learning outcomes has been added into the course descriptions, Cross disciplinary and Design Build projects has been developed and implemented, Teacher teams has been formed and knowledge about CDIO has been disseminated into the teacher group

In the programme all courses contains projects of varying size, and each of the first 4 semesters contain a cross disciplinary project placed in a 3 week project period placed at the end of the semester, the project period are connected to a project carrying course which like the other courses in the semester runs for 13 weeks, two of these are CDIO Design Build courses, which are placed in the 1'st and 4'th semesters [8].

DTU B.Eng. Education in Electronics

1. Semester	2. Semester	3. Semester	4. Semester	5. Semester	6 + 7. Semester
Calculus and algebra 1	Matematics 2	Probability and Statistics	Physics	Elective Courses	Elective Courses
Calculus and algebra 2	Advanced Programming	Engineering Electromagnetics	Design of Digital Systems		
Elementary Programming	Analog Electronics		Analogue design		
Electrotechnics		Linear Systems, Digital Signal Processing and Signal Processors	Linear Control Design 1		Industrial Internship
	Digital and Data Technique		Electrical Energy Systems		Final Project
Project in Electrotechnics					

Figure 2, DTU B.Eng. program in electronics, 1'st to 4'th semester are CDIO based.

White : Cross Disciplinary Projects (CDP)
Light orange : Contributors to CDP
Light gray : Minor or no contribution to CDP
Dark gray : No contribution to CDP

MASTER DOCUMENT

In order to implement the CDIO syllabus a study plan committee was formed. The task of implementing the Syllabus standards in the DTU B. Eng. programme in electronics was eased due to a major revision of the study plan carried out in 2006. The primary focus on the former revision was on technical knowledge and on assuring a better progression between the courses. Due to knowledge about the upcoming CDIO implementation, places for implementing cross disciplinary courses were also pointed out. The study planning committee was therefore able to concentrate primarily on the Design Build projects and the soft skills implementation, the CDIO syllabus competences 2-4. To describe the proficiency levels of the CDIO syllabus competences, all course was assigned learning objectives using Bloom's taxonomy [6] see figure 6.
An in depth description on how the soft skills were distributed across the courses, how the competence matrix was created, and which Bloom levels was documented in a master document for the first 4 semesters in the programme.

One of the challenges that emerged quickly was the question of progression in Communication skills (CDIO Syllabus 3.2), how do we assure, that the students improve their skills in writing technical reports? How do we measure this improvement over time? And how do we distribute the responsibility for doing this between the courses.
Another challenge of a similar nature was, how do we assure progression in the students skills regarding project management, project planning and working in larger groups? And which courses are responsible for teaching these fields?
In fact a lot of critical interfaces/agreements between the courses were disclosed and many worries about this were expressed in the study planning committee because, how can it be assured, that these sometimes very fragile but important interfaces are maintained over time and when teachers change.

All courses are described in the course database [4] using a common information entry form. The course database is directed outwards towards the users, i.e. present and potential new students. Apart from this the teacher, responsible for a course, will have his personal records about how the course is taught including detailed plans, notes, examples, exercises, etc. Other student relevant material is placed on Campusnet [5], which is part of the university intranet.

The study planning committee found, that none of the above listed information storage facilities were suited to keep the information needed to document the CDIO course interfaces, the information could be left at the teachers responsible for the individual courses, but when a teacher leave the responsibility of a course to another teacher, the experience is, that much of this interface information are lost in the transition, thereby making the CDIO study plan vulnerable to personnel changes.
The solution found by the study planning committee was to write a master document [3] that keeps this information together with all other relevant information about the education. The master document contains information related to every individual course in the curriculum as well as information common to the whole programme. The structure of the master document is depicted in figure 3 and an example of one document page for one course 31022 is depicted in figure 4.

The Competence profile for the complete B.Eng. program [9]

A graphical overview of all the courses in the curriculum showing the progression of Technical knowledge and reasoning see Figure 1.

For each course in the curriculum (Figure 2)

- Progression within the field of Technical knowledge and reasoning, and collaboration between this and other courses
- Contributions to Design build project or Cross disciplinary project
- Learning objectives from the DTU version of the CDIO syllabus to be addressed during the course
- Explicit learning objectives to be placed in the course database

A figure describing the progression of CDIO syllabus top level competences

A soft skills competence matrix showing the Bloom level reached for all courses versus all CDIO competences in the CDIO Syllabus (Figure 5)

A list of all course descriptions

Figure 3, Structure of the master document

Progression within the field of "Technical knowledge and reasoning" and collaboration between this and other courses

The course builds upon the course 31031 Electrotechnics and adds competences regarding time varying signal analysis of electronic circuits.

The course contains AC and transient analysis of circuits, filter theory, semiconductors (MOSFET) DC analysis and small signal equivalents. To visualise these fields the simulation program PSpice is used.

The course exploits the subjects Laplace and Fourier analysis which are treated in the course 01964 Mathematics 2 which runs in parallel with 31022, examples from 31022 are likewise used as examples in the mathematics course

31022 contain extensive laboratory exercises and a larger project, this project is a part of the 2'nd semester cross disciplinary project performed in collaboration with the course in digital design 30080.

The course gives competences within the fields of: designing simple filter circuits using discrete components, and calculating frequency and transient responses for linear circuits.

31022 forms the basics for the advanced electronics course 31037 and control theory 31301

Design build project or Cross disciplinary project:

The project covers the production of an RIAA amplifier which are designed and implemented on a PCB

The 2'nd semester cross disciplinary course is basically an instrument designed to measure the frequency response, the instrument are used in an exercise and under the development of the filter circuit. The RIAA circuit at also used as a well defined test object during the remaining part of the cross disciplinary project.

The groups working on the RIAA projects are not necessarily the same as in the other courses on 2'nd semester

Learning objectives from the DTU syllabus to be addressed during the course

Group 2: PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES

2.2. Experimentation and knowledge discovery

Measuring methods to be used in connection with AC and transient analysis are taught in connection with the laboratory exercises and under the implementation of the filter amplifier. Bloom level 3 (Apply)

Group 3: INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION

3.1. Teamwork

The course exploits and builds upon the acquired skills in collaboration and group work. The students must plan and distribute of work and responsibilities for the project. The work is carried out in groups of 2-4 persons. Bloom level 2 (understand)

3.2. Communication

A written report are made describing the project work- designing and implementing a filter amplifier- the report standard is applied here, half of the report is reviewed during the course and the full report evaluated as part of the oral exam. The oral examination of the course must include an oral presentation of part of the project report. Bloom level 2,3 (understand, apply)

Group 4: CONCEIVING, DESIGNING, IMPLEMENTING AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT

In the course elements of system design (4.4), implementation (4.5),and operating (4.6) are used although no specific bullets covering these aspects are added into the course description in the course base

Explicit learning objectives to be placed in the course database

- use measurement instruments and measurements to recognise circuit functionality
- documentation of project work in the form of a technical report
- cooperate in a team and delegate responsibility to team members

Figure 4. Detailed example for the 2'nd semester course "31022 Analog electronics"

PROGRESSION OF CDIO COMPETENCES "SOFT SKILLS"

Apart from the mapping of the Technical skills, as shown in figure 1, the master document also contains a mapping of courses contributing to the CDIO competences.
In order to map and assure progression in the CDIO competences, Blooms taxonomy has been chosen as the tool to describe the levels of progression expected in the different courses, and the proficiency levels reached for all courses related to the CDIO syllabus competences, the mapping is depicted in the competence matrix shown in figure 5

		2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	4.1	4.2	4,3	4,4	4.5	4.6
01906	Diplomath 1				1		1		3						
01907	Diplomath 2				1		1		3						
02318	Introductory programming for Diplom-E														
31032	Elektrotechnics		2				1								
31033	Project in Elektrotechnics	1	3	2			1	1					1		
01964	Matematics 2				2										
31022	Analog electronics 1		3				2	2-3				1			
02319	Videregående programming for Diplom-E												2		
30080	Digital and Datatechnique	2-3		3			2-3	2-3				1	2-3		
02323	Probability and Statistics				3										
31035	Applied electromagnetism		4												
31038	Linear systems and Digital signal processing	U2-3										2			
10917	Physics											U2			
31037	Analog design														
31300	Linear Control Design 1													1	
31028	Digital systems														
31036	Electrical Energy systems	4	U4	4				U3							3
praktik	Internship					2				1	1				
Final level		**4**	**4**	**4**	**3**	**2**	**3**	**3**	**3**	**1**	**1**	**2**	**3**	**1**	**3**

Figure 5, Competence matrix for the courses

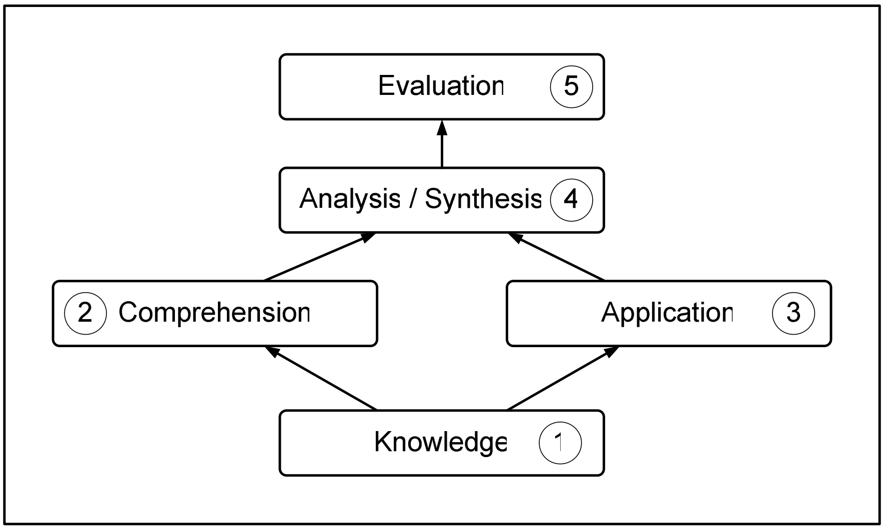

Figure 6, Blooms taxonomy simplified

A most important part of the engineering programme development and implementation is assuring good compliance with industry needs [1], at the beginning of the programme development the advisory board for the Department of Electrical Engineering was asked to evaluate the CDIO syllabus competences in relation to the electronics industries needs and rate their importance on a scale from 0 to 5. At the same time teachers responsible for the programme were asked to make an apriori competence matrix for the programme and use Blooms taxonomy to describe the proficiency levels for the CDIO competences.

At the end of the programme development an aposteori competence matrix was created based of the competences, that were the result of the programme revision, and stated in the master document. The proficiency levels of the new programme were then benchmarked in relation to the information gathered at the beginning of the programme design process, the benchmark is depicted in figure 7.

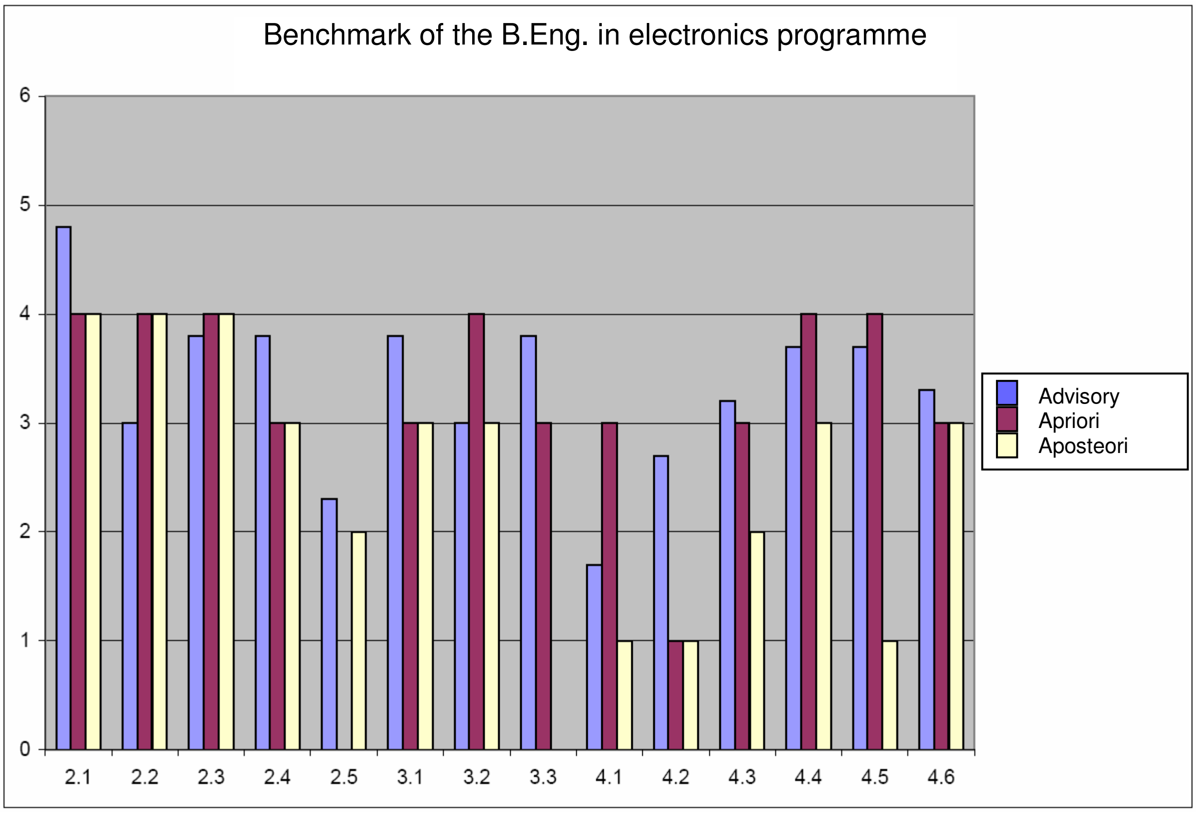

Figure 7, Benchmark of the B.Eng. in electronics programme

As figure 7 depicts importance 0-5 and bloom proficiency levels 0-5, in the same plot, a comparison can be difficult, it can however be concluded that the proficiency level obtained in the prior programme (apriori) generally have good correlation with the importance levels stated by the advisory board. The competences 4.1 “External and societal context” and 4.2 “Enterprise and Business context” have a rather low score both in importance and proficiency level.

Comparing the proficiency levels from the apriori and aposteori matrices a god correlation exists except for the points 4.1, 4.2 Social and Business content, which shows a low weight on these topics, quite similar to the survey carried out on MIT and depicted in[7]. Also competence 4.5 is lower than expected, this is important, as it is the implementation part, the cause for the low proficiency level lies in the way the programme committee understands “implementation” in the electronic engineering context, and is not to be mistaken as an expression for low focus on implementing electronics circuits in the curriculum.

ASSESMENT CHALLENGES IN PROGRESSION OF SOFT SKILLS

When adding the learning objectives to the course descriptions they obviously have to be testable furthermore there is a demand for progression within the skills in the 4 semester mandatory period. The study planning committee found several challenges going through the different learning objectives, especially the CDIO competence points 3 regarding teamwork and communication raised several questions.

-How is it possible to measure progression in report writing skills?

-How is it possible to measure progression in the ability to cooperate, plan and distribute workloads when working in groups?

-If testing in these skills how do we assure that the assessment by teachers on different semesters fits the level expected?

For reporting skills a teacher might rate a report from a first semester student as poor compared to a 4 semester students report with much more experience, this would be a serious mistake, as the reporting skills are expected to improve over time.

It is necessary to describe which report levels are expected for each of the 4 semesters to assure, that the students know what level to comply to, and similar to the teachers what they should expect, when they grade the reports. Having a common reporting standard was discussed, but has not been implemented, because there are among the teacher group variations in the way they view reports, and also because different tasks calls for different report types. Instead the students are gradually exposed to the topics, following the path described below.

Report writing skills:

1'st semester:
A partially filled report is handed out to the students, and the students add their contributions/results into this report.

2'nd semester:
A partially filled report is handed out to the students and the student add their contributions into this report, the students submits their report for review and receive the reviewers (teachers) comments, the student adjust the report according to the received feedback and resubmits the report.

3'rd-4'th semester:
The students submit full reports

Ability to cooperate, plan and distribute work when working in groups:

1'st semester:
In the Design Build project the group size is 2-3 persons, the group has to write a small project plan consisting of delegation of responsibility for different tasks in the project, and also a Gant plot showing resource allocation over time.

4'th semester:
In the Design Build project the group size is 10 persons, here the project management part is larger because of the large group, group leadership, and group meetings are now necessary elements that has to be carried out in order to utilize the large amount of working hours in a sensible matter. Some lectures are given in the subject of project management, and reference material is available.

Figure 8, Progression in soft skills related to CDIO syllabus Group 3: Interpersonal skills, teamwork and communication.

IMPROVED STUDENT EVALUATIONS

Evaluation of the effect on the learning outcome as a result of implementing CDIO elements should preferably be based on evaluation before and after the implementation with all other factors unchanged. The courses 31022 Analog Electronics (described in figure 4), had a major change to fit the new CDIO requirements, and is otherwise unchanged (The technical and scientific curriculum, as well as the textbooks and the teacher, were the same).

All courses in a semester are at DTU evaluated by the students using a standardized questionnaire. The result is shown in figure 9 for the course from 2007 to 2010 (prior to 2007 the questionnaires were not comparable).

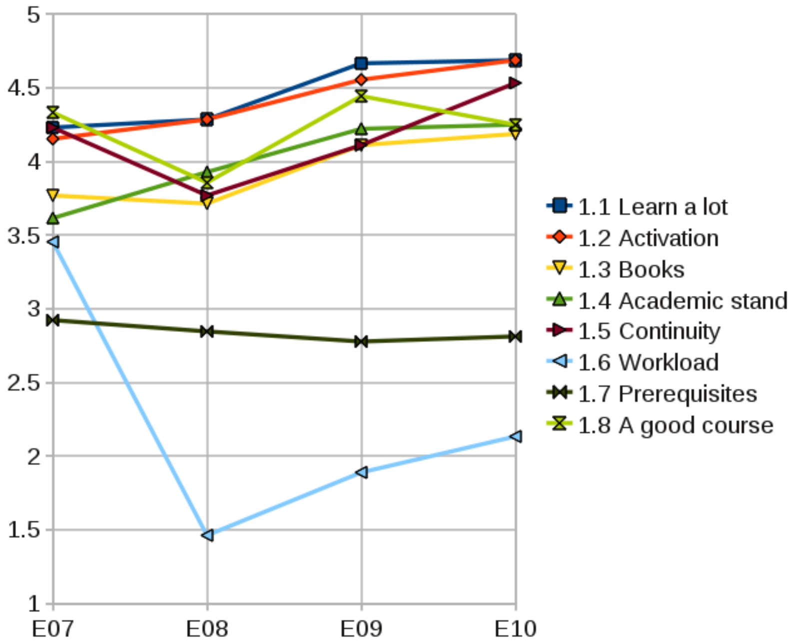

Figure 9: Development in average student evaluation of the 31022 course. The CDIO elements were introduced in the fall 2008 (E08). The work load increased significantly, but so did the general satisfaction with the course. The scale 5 is strongly agree and 1 is strongly disagree for a positive formulated question, for work load 5 is much less and 1 is much more than the norm.

Six of the eight questions were formulated positive on the subjects indicated on figure 9, where 5 is strongly agree to the question and 1 strongly disagree. For the work load the scale is 5 for much less and 1 for much more than the norm for 10 ECTS points. For Prerequisite requirements the scale is 5 for too low and 1 for too high.

The CDIO elements were introduced in 2008 – with the main element being a continued project, where a partially completed report twice has to be handed in for review, and the complete report at the end. The lectures and related exercises were further adjusted and rescheduled to fit the progress in the project.

The major change in student evaluations was in the work load, where the new method required much more work. At the same time the satisfaction with the course did not drop, and at the next course, after some streamlining, the satisfaction level increased significantly, and maintaining the rather high workload at the same time.

This positive outcome can only be seen as a consequence of the changes introduced based on the added soft skill learning objectives and the new teaching attitude from the work with CDIO.

One of the student comments, after the course in 2009, is almost too good to be ignored: ”The course is well planned, and almost the mother of all courses. The practical parts make it compelling to know the theory, and at the same time create curiosity for the subject.” (Translated from Danish).

DISCUSSION

Benefits

The benefits of having a master document are numerous, it can be used when:
- presenting the course for potential new teachers, to show in depth what is expected
- presenting the education as a whole, one source of info controls the whole education
- describing the agreements made between courses coming from different institutes
- describing the hard skills interfaces in the form where do we come from and where do we go, summing up which skills are prerequisites for courses on later semesters.
- describing the course role and contribution to a cross disciplinary project
- describing the design build project if one exist in the course
- describing which soft skills should be taught in the course
- stating the level of soft skills taught in the course
- teacher’s coming from other educational levels needs help to adapt to the methods and levels in the course.

Future Challenges

The master document has been designed and 1’st and 2’nd semester courses and cross disciplinary projects has been described in the document, 3’rd and 4’th semester courses have only been given one time and are still in the moulding process the master document is therefore not complete on these semesters and some further work is necessary to complete the document.
The teacher’s response to the master document has to be evaluated.
All individual courses are evaluated at the end of the semester, figure 9 depicts the result of one of the courses in the programme but similar comparisons has to be performed over the remaining courses and an analysis on the whole program has to be made.
Furthermore the programme is audited on a 5 year interval basis and an audit as a CDIO based program has not yet been scheduled.

CONCLUSION

The work done implementing CDIO in the B.Eng. in electronics programme has shown, that during the process of building an educational programme, much information are generated and many decisions made in order to produce the program plan and the corresponding course plans containing the learning outcomes for the courses.
The master document proposed complement the course plans, by keeping the records of exactly why a particular learning outcome has been put in the course plan, and what particular obligations the course have in relation to the whole program. The value of having the master document will grow with time, as the program matures, in fact it has already proven to be very useful in a situation, where a teacher heavily involved in the CDIO implementation had to be replaced. The master document also assures, that the quality and especially the culture in the education can be maintained for as long, as it is found necessary.
The document of cause has to be reviewed on a regular basis and also modified according to the changing demands on the education.

References:

[1] Bruun, Erik Claus Kjærgaard
"A MODEL FOR THE DEVELOPMENT OF A CDIO BASED CURRICULUM IN ELECTRICAL ENGINEERING"
7th International CDIO Conference 2011 at DTU, Copenhagen, Denmark

[2] Vigild, Martin Etchells; Willumsen, Louise Engberg; Borchersen, Egil; Clement, Karsten; Bjerregaard Jensen, Lotte; Kjærgaard, Claus; Klit, Peder; Sparsø, Jens "COMPARISON AND CLASSIFICATION OF DESIGN BUILD PROJECTS IN DIFFERENT ENGINEERING BACHELOR PROGRAMS". Proceedings of the 5th International CDIO Conference, Singapore 2009.

[3] Kjærgaard Claus, Brauer Peter, Andersen Jens Christian, Jacobsen Michael
"Implementering af CDIO på Diplom-E uddannelsens første og andet Semester" Rev. 3, Juni 2008;
DTU.

[4] www.kurser.dtu.dk

[5] www.campusnet.dk

[6] Bloom B. S. (ed), 1956: Taxonomy of Educational Objectives, Handbook I: "The Cognitive Domain." Addison Wesley Publishing Company. 2007 Springer Science + business Media LCC, ISBN 0582280109

[7] Crawley Edward, Malmqvist Johan, Ostlund Soren, Brodeur Doris, "RETHINKING ENGINEERING EDUCATION, THE CDIO APPROACH", Figure 3.8 page 67, ISBN 978-0-387-38287-6

[8] Træholt Chresten, Holbøll Joachim, Thomsen Ole, Kjærgaard Claus
"CDIO – THE STEAM ENGINE POWERING THE ELECTRIC GRID"
7th International CDIO Conference 2011 at DTU, Copenhagen, Denmark

[9] Competence profiles for the B.Eng. in electronics.
www.dtu.dk/upload/administrationen%20-%20101/aus/kompetencebeskrivelser/kd_elektro.pdf

[10] Kjærgaard Claus, Brauer Peter, Andersen Jens Christian.
"CDIO PROJECTS IN DTU's B.ENG. IN ELECTRONICS STUDY PROGRAM"
7th International CDIO Conference 2011 at DTU, Copenhagen, Denmark

[11] Malmqvist, J., Östlund, S., Edström, K.(2006) "INTEGRATED PROGRAM DESCRIPTIONS – A TOOL FOR COMMUNICATING GOALS AND DESIGN OF CDIO PROGRAMS".
Proceedings 2nd International CDIO Conference, Linköping, Sweden.

[12] Malmqvist, J., Arehag, M. (2007) "EXPERIENCES FROM USING INTEGRATED PROGRAM DESCRIPTIONS TO SUPPORT PROGRAM DEVELOPMENT."
Proceedings of 3rd International CDIO Conference, MIT, Cambridge, Massachusetts.

Biographical Information

Claus Kjærgaard received the B.Eng. (hon.) in electronics engineering from the Danish Engineering Academy 1984. In 1987 he joined the Danish Engineering Academy, which is now part of DTU. He is currently an Associate Professor at the Department of Electrical Engineering, DTU. For many years his research was focused on reliability of repairable electronic systems. During the last 10 years his work has been focused on teaching and developing courses and study plans in the field of analog electronics and hybrid microelectronics and on research in these fields. In 2006 he received the reward as best teacher in the B.Eng. educational programs at DTU. Since 2005 he has been head of studies for the B.Eng. program in electronics and has been responsible for the implementation of CDIO in this program.

Jens Christian Andersen received his B. Eng in electronics engineering from Københavns Teknikum in 1982. After a career in engineering in the Danish Airforce he finished his Master in 2003 from DTU, and in 2007 he was awarded a ph.d. in mobile robotics from DTU. He is currently Assistant Professor at the Department of Electrical Engineering at DTU. His research field is mobile robotics. His teaching portfolio include a number of fundamental courses in electronics at the B. Eng education. He received the annual reward for ”excellent course and teacher” in 2010.

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