

# **Alignment of Student Expectation and Teacher Communication of CDIO**

## **- Building a New Education Using CDIO**

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### **ABSTRACT**

By September 2011 the National Food Institute, part of the Technical University of Denmark (DTU), started a new education in food analysis. The education is a Bachelor of Engineering program spanning over 3½ years. At DTU a decision was made approximately 7 years ago that CDIO should be implemented as a teaching paradigm in all Bachelor of Engineering education programs. Hence this new education is developed in a CDIO context. At the National Food Institute this gives some special challenges. Being a former research institute, education has not been one of the cornerstones in the institute and very few employees had the pedagogical knowledge of teaching and had at the most a very limited teaching experience from occasionally being guest lecturers. At the same time, students at this new education program in food analysis have a quite different profile compared to the classical engineering students at DTU.

To acknowledge these challenges, the central teaching developing unit at DTU, Learning Lab DTU, and the National Food Institute started a project to align the student expectation with engineering education of the coming teachers' in the principles of CDIO. Students just graduating high school were not schooled to take responsibility for their own acquiring of knowledge and were adapted to being told what to do and reminded by the teachers. Teachers on the other hand were more focused on research and discipline.

The aims of this project are twofold. One aim is to find the right strategies to implement CDIO as a teaching paradigm and to qualify the teachers to teach in accordance with the CDIO principles and methods, at the same time as this new education is constructed. Another aim is to work with, and investigate, the students' development in a CDIO context with special focus on their perception of engineers and engineering practice. The overall question is what impact CDIO as a teaching paradigm has on the students' formation of their identities as engineers. To investigate and seek the answer to this question and to understand what strategies work most efficiently to implement CDIO within the conditions of this education, the project includes a longitudinal study including focus group interviews with students and a systematically follow up and triangulation of the students' results and grades linked to the teaching methods each study year. In this paper the first initial study from the students' experiences from the first year of their education will be reported. Already during the first year a development in the way they perceive their education and their future roles as engineers can be reported.

### **INTRODUCTION**

DTU is running a total of four kinds of education programmes: Bachelor of Engineering, Bachelor of Science and Technology, Master of Science and Technology and PhD programmes. The aim is to provide the students at DTU with educations of the highest possible quality. To be successful with this aim DTU continuously and systematically strives to develop both the understanding of teaching and learning among the educators and the teaching practises. In order to do so DTU offers a variety of activities including mandatory teacher training program, training courses, seminars, and development projects.

In 2004 it was decided to adopt CDIO systematically at DTU in the 3½ year Bachelor of Engineering (with 10 different engineering majors) in order to distinguish it as a programme of applied science directing candidates directly towards jobs in the industry. Another reason for adopting CDIO was that it serves as a framework for quality improvement and assessment of educational activities giving educators a common language and a goal for higher standards. Adopting CDIO in the Bachelor of Engineering programmes has been a long process spanning over several years, and many experiences have been made from this process. In many ways the adoption has been successful. CDIO now is the overall teaching paradigm in a whole cohort of education programmes, fully implemented, and many educators are engaged in

teaching in a CDIO context. CDIO has provided an additional frame work for the general teacher training activities at DTU where the educators can increase their understanding and knowledge about teaching and learning. Thus it seems that the adoption of CDIO contributes to the development of a broader knowledge and understanding of some of the general principles to efficiently support student learning in Higher Education.

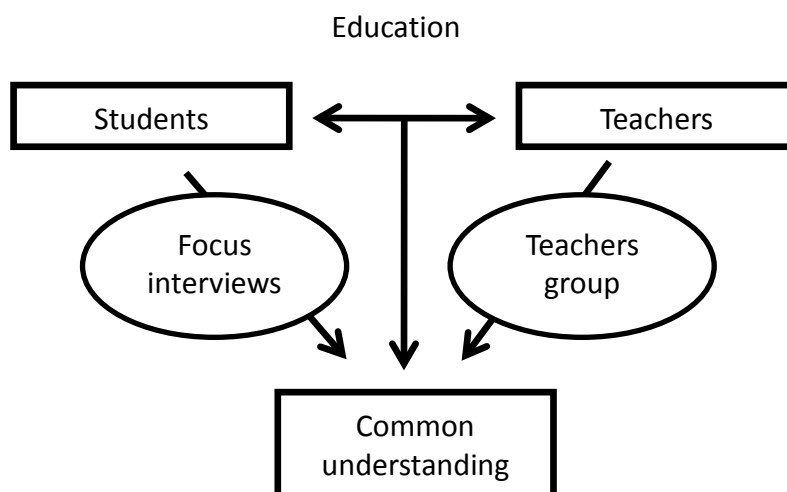
Even if at DTU a clear framework for the Bachelor of Engineering educations provides a distinguished framework for educating engineers, the situation at the National Food Institute of Denmark differs from many of the education programmes at DTU. Coming from a practice based on research when merged into DTU in 2007 there is a huge effort to be made in order to change the activities at the institute to also include teaching of students in an engineering context. Generally, the staff at the institute has a background in biology, not in engineering. Those circumstances stress some challenges when it was decided to start a new education in food analysis for which the institute would take the full responsibility. The education was started because of the acknowledged need from the Danish food industry that engineers with those competences are of strategically use in the future. This means that the entire area is complete new.

## **OBJECTIVES OF THE EDUCATION**

The Bachelor of Engineering in Food Analysis gives a solid application-oriented knowledge of chemistry, microbiology and biochemistry with a focus on the protection of quality, hygiene and control precautions of the food chain from production to the point of preparation. The professional competences of the education have a direct connection to the practice in the business community and relevant Ministries.

## **ALIGNMENT OF UNDERSTANDINGS IN CREATION OF AN EDUCATION**

To sum this up, the whole context, content and understanding for this engineering education must be created and build from the very beginning in parallel with the development of the courses and the curricula in the education. The only thing that existed in the beginning of this work was the context provided by CDIO as a framework and teaching paradigm. In order to succeed with this huge task in creating a new education under those circumstances, the students' expectations to their education and to their future roles as engineers, and also how the teachers perceive and communicate the aims and objectives of the education and the meaning of being an engineer, need to be aligned. A common understanding must be created among all the groups involved in the education. In order to do so a project is created involving all students, teachers and the industry in order to form a strong fundament for the education and the students' professional development as engineers. Different activities are created based on the needs and prerequisites and with the common goal to create this alignment in understanding. At an early stage a teacher team was created following one of the basic CDIO ideas. The students are closely involved in the education and there is an ongoing communication between the students and the program management. The students' experiences are followed in focus group interviews once each semester. The industry is involved by representatives in advisory boards and an ongoing dialogue with the industry is important. Another aim is to create an education program which is clearly showing the scope of being an engineer within this area in order to attract students who are ready to engineer, also an important aim according to CDIO [1]. The context in which this education is developed can be described in the following figure.



Project model of alignment of students and teachers' expectations and understanding.

## **CREATION OF A COMMUNITY OF PRACTICE TEACHERS, STUDENTS AND THE INDUSTRY**

In order to form a common understanding about the objectives, means and methods in the education, but also about what engineering in this field is, the idea of communities of practices can be used as a guideline and theoretical framework [2]. The concept of community of practice takes its starting point in social learning theory, where learning is understood as the creation and construction of knowledge and understanding in interaction with others. This describes in a suitable way the process in this project and the development of this education [3].

The underlying idea of a community of practice is that people form a social context around a common practice. Newcomers to the community is moving from the periphery of the community towards the middle of it, where the more experienced participants are in a process of social learning where the content is not so much in focus as how it is dealt with. Central in this process is that all members in the community experience a membership and the community is open for every participant. Another central trait in a community of practice is that newcomers are allowed enough legitimacy to be able to act as fully-fledged members [4]. That the participants in the community can elaborate on the practice and feeling acknowledged in doing so, in order to create the foundation for the transition of understanding which make learning possible in the context.

Though this community of practice is entirely new, there is no center in advance for newcomers to relate to and develop an identity towards. Hence, no structure of power or ownership pre-exists, leaving possibilities for everyone to participate in the creation of the understanding and practice along the way in the forming of the identity in this community. Forming this identity is a dual process between identification to the practice and its members and negotiability of the influence of the meaning created [2]. Using the concept of communities of practice corresponds nicely with the use of teacher teams stressed as in a crucial part of the CDIO framework [1]. The focus in this community of practice is engineering education and engineering in the field of food analysis and to create the alignment of understanding among both the teachers and the students. Since the education is entirely new as well as the use of engineers within this area, the industry is also an important counterpart to be involved in the creation of the education and of the understanding of its scope and objectives. This is a process of iteration which will continue while the process of development of the education proceeds and new experiences are made.

In conclusion, this community of practice is shared by teachers affiliated with the education, students and the Danish food industry who each need to relate to this new education of Bachelor of Engineering and adjust their previous thinking towards a common understanding. CDIO as a teaching paradigm is also a part of this understanding and something for students, teachers and the industry to relate to and learn to understand. One can claim that CDIO provides a good framework and tool in this process due to the clear structures and description of guidelines to educating engineers. Understanding CDIO as a teaching paradigm is also within the objectives of this community of practice. Another more general reason for using the idea of social learning as a tool for enhancing teaching practice and student learning in an education context is that research shows, that it has a positive effect on the quality of student learning [5].

## **CDIO AS A TEACHING FRAMEWORK FOR THE EDUCATION IN FOOD ANALYSIS AND FOR THE COMMUNITY OF PRACTICE**

The overall aim with CDIO is to create a framework for preparing the students for their professional life as engineers. One of the problems CDIO are meant to address is the gap which developed between engineering education and engineering practice while the educations developed from a practical based discipline to a more academic one [1]. In the development of the education in Food Analysis, this is very much a matter, hence most of the teachers are new in their role as teachers and mainly with a background in biology and need to rethink their professional competences into an engineering practice in order to teach engineering students and prepare them for a professional life in the industry. In this context the CDIO standards and syllabus both provide a very useful frame in order to develop the education.

### **THE TEACHERS' GROUP**

The principles of CDIO were used by creating a teacher's group of responsible teachers for courses in this education. This group consisted of 15 teachers and most of them had a lot of experience as researchers in the former National Research Institute with only participating as guest lecturers in teaching. A competence matrix was built for the first three semesters (2011-2012) and levels for defining the learning outcome of the whole education were assigned according to Blooms Taxonomy [6] for each individual course collectively [6]. The matrix for the last semesters will be build according to the knowledge of the first three semesters. By using this approach, common ownership was ensured of the progress in knowledge and made the common ground for the different disciplines, visually creating networks along the education for progress as well as break down scientific disciplinary borders. Furthermore, each new course was presented to the team to inspire

teachers responsible for creating new courses later in the study curriculum. Student knowledge and expectation was presented to the team for reflection and understanding, making it a common goal to create a mutual platform for learning. Meetings in the teacher team happen on a regular basis to create understanding and identifying the need for teacher support to the understanding of teaching in a CDIO context.

## THE COMPETENCE MATRIX

The competence matrix was built over a series of meetings in the teams of teachers while creating a series of new courses. For this education common courses in mathematics and basic chemistry are followed with students on other Bachelors of Engineering educations but a total of 9 new semester courses with focus on the understanding of food chemistry, food microbiology and the effect and risk of these disciplines had to be created. On the first semester two new courses should give the students a basic approach, while second semester focused on chemistry and the third semester focused on microbiology leaving the last semesters for collecting and using the general obtained knowledge practically in internship, understanding the effects on the human body (toxicology and risk assessment and the final graduation project).

		general organic and inorganic chemistry	Toxicology	Biochemistry and molecular biology	Microbiology and aseptic techniques	Food chain from raw materials to final products including best practise	Statistics and multi variant analysis	Risk assessment and ISO certification	Self-regulation and ISO certification	Laws	Quality control	Supervision and audit	Laboratory safety	Ethics in food
1. semester	Food analysis (design-build)	1	1	2	3	1	2				1		2	
	Introduction to food					1				1				2
	Basic mathematics						2							
	Inorganic chemistry	2		2										
	General chemistry	2												
2. semester	Organic chemistry	3												
	Biological chemistry	2		3	3	1	1			1	3		3	
	Improved mathematics						3							
	Design-build course in chemistry	3	1	1		1	3	1	1	2	2		3	1
3. semester	Analytic chemistry	4-5	1				3	2			3			
	Statistic						3							
	Food production	3		1	2	4		2	3	2	4	3		1
	Design-build course in microbiology	3	1	4	4	3	3	3	3	2	3	2	4	2

1= Basic knowledge, 2= Understand, 3= Apply, 4= Analyse and construct and 5= Professional evaluation according to Blooms Taxonomy [6]

On each semester a design-build course is included and this should ensure knowledge obtained during the course of the semester. For each of these courses a food product is produced and methods for analysis are implied. On the first semester beer and bread were produced, while in the second semester sushi will be produced, and in third semester the production of

sauces will be attempted. Each of the first three semesters has a theme inside the major disciplines like physics, chemistry and microbiology.

## **REGULAR TEACHER TRAINING**

In order to enhance the teachers' understanding of student learning and facilitate their development of teaching skills and qualification, the National Food Institute systematically uses the mandatory teacher training program at DTU. In this education the focus is on active learning methods and the CDIO principles are explicitly addressed. They are also forming an implicit red thread through the program as they embed many of the important traits to facilitate student learning in higher education. Hence, being a decision from management level at the department with the clear connection to the development of the education program, this strategy has a frame which enforces the outcome of the education. The management level's endorsement is an important factor for the success of teacher training [7].

## **THE STUDENTS' GROUP**

A total of 12 students consisting of 3 males and 9 females enrolled on this education in September 2011. The average age was 21, 8 years. Almost all the students came from technical high schools in Denmark before applying for admission at the Technical University of Denmark. 6 of the students had applied directly for this education while the rest had changed from majors in Building Design and Chemistry- and Biotechnology. The students play an important role in the community of practice concerning the development of the education program, and they are involved in many activities related to their education. For example, they are represented in the study board. They are accordingly involved in the communication and marketing of the education and they are also a part of many other activities. In order to follow their professional development as engineers, and according to the idea of CDIO and gaining a greater understanding of how CDIO works, the students are followed in a more systematic way.

## **FOCUS GROUP INTERVIEWS**

Through a series of focus group interviews, which is a semi-structured interviewing form [8], the students' expectations to their role at university and for this new education are exploited and their understanding for the goal and principles of teaching are enlightened. Through interviews and discussions the students are made aware of the attempts to align learning principles and progress in understanding, as well as their need for guidance. The first interview took place in October 2011, approximately one month into their studies. The second interview took place during their second semester. It is our plan that we interview the students again each semester throughout their education, to follow up on the previous interview. Also, we want to talk to the students on a regular basis so we can measure the level of progression and ensure that the students are able to follow the teachers plan for progression through the education. We have to consider that we are dealing with a new education and these are the first students entering, so it is important that we are receptive to the students and their input and through these interviews they can help us tremendously. The students are becoming relevant actors in forming the education.

The 2<sup>nd</sup> round of interviews were conducted on Wednesday the 28<sup>th</sup> of March 2012, and 1 hour was allotted to each interview, but fortunately the students were eager to talk and discuss, so each interview lasted 1½ hours. Of the 15 students, 9 showed up and were divided into two groups. The Educational Consultant interviewed one group, and the Educational Coordinator interviewed the other in a separate room. Both interviewers used dictaphones to record the interviews.

The students were asked the following:

- 1a. What is your impression of the education so far? (Write 3 items on a post-it. Write, read aloud, discuss. Can you agree on 3 things?) 1b. If you are unsatisfied, what can we do to change that?
- How has your first semester been? (Everyone mentions 1 thing. What do you think of when you hear this? Give an example).
- The courses individually: (They are presented with a list) 1a. What have you learned? 1b. How have you learned?/ In which situation is it easier to learn? 1c. What is your opinion of the fact that some of the teaching material and teaching is in English?
- 1a. Why have you chosen to study a bachelor of engineering? 1b. Do you think there is a coherence between your first impression of the education, and your concrete experience? 1c. What is your opinion of the structure of the education? 1d. Have you heard of CDIO? And how will you describe it? Is there any association to the industry during the education?

- If you consider all of this (the teaching, the structure, the idea of yourselves and becoming an engineer in the future), do you think there is a coherence? (Answer individually). Do you have any thoughts of your future as engineers?
- What would you say (if anything) to Head of Studies, Lars Bogø, if he was to join us right now? And what would you say to Communications Officer, Gitte Frandsen, about the marketing of the education?

The first questions (concerning their impression of the education this far) were actually a repetition of the first interview in the autumn of 2011, but we wanted to know if their impression had changed, or if it had remained the same. Sometimes their answers varied, eg. when one of them answered that she was a bit bored because she was not attending as many courses as most of the others in her class. Some of the other students thought they had too much to do this semester. Mostly, their answers had to do with the courses they were attending at the time of the interview, and so their answers varied. This applies for the interviews in the autumn as well as for the interviews in the spring.

In this chapter, our focus will mainly be on the last three items on the list.

Although, we were glad to discover that all the students were even more satisfied with their choice of education, now that they have gone through half of their 2<sup>nd</sup> semester. It seemed as if the more food related courses they attended, the more interested they became. They asked us if the teachers could take them on more field trips to companies, such as Carlsberg, the Danish brewery, which they have already visited. The company visits reassured them, that there are in fact companies out there that would like to hire them when they graduate. One student said this: "When we visited Carlsberg we discovered, that the kind of analysis we work with, is actually used at a place like Carlsberg. So if we should get a job in a company like that, we will know that we are well prepared, because of the lab work and analysis we have done".

The students expressed their concern about future job opportunities and said that they definitely did not want to have a job in the Danish Food and Veterinary Administration, handing out smileys to restaurants and food companies. But they are also worried whether they will be able to get an internship placement in a company when they get to their 5<sup>th</sup> semester. They were very clear about this, but they have already taken some initiative by attending a job fair at the university, arranged by a Danish student organisation called DSE. This led to promising conversations with some of the most important food companies in Denmark, such as Chr. Hansen, Danisco and Dupont. This experience was important to the students, and both students and the people in charge of the education (Head of Studies, teachers and student administrative employees) need to work together to ensure that all students will get an internship placement.

Also, we were curious to discover how much the students knew about the CDIO Initiative, and if they were aware of the four levels in each course. That is to say, the courses offered by the National Food Institute. We did not go into details with CDIO concept, but the students made it clear that they were able to tell what the letters C-D-I-O stood for, explain what each word meant and how it was visible in the courses. They gave us the impression that they had almost been told about the CDIO concept too much during the 1<sup>st</sup> semester, but on the other hand, they were now able to explain it to others.

The students' view of themselves as engineers is still a bit vague, as they have only just begun we can see a progression in the students' perception of themselves as engineers. One of the students their studies and they are quite aware that they are the first students to take this education. But still, after these two interviews said that "All kinds of engineers can, in principle, get jobs in the same companies". This particular student had previously studied Bachelor of Engineering in Mechanics, before studying food analysis. Actually, several of our students have changed from other educations at DTU, and because of this their perspective on their future as an engineer is more likely to be broader.

We asked the students if the structure of the education supported them in their development to become engineers. One student said that she matures and evolves from one semester to the other, every time they do lab work. Another student mentioned the feeling of becoming more independent as a human being, and that it was nice to have, not only a professional development, but also a personal development during his studies. When asked what contributed to this, the answer was very clear: The courses and the teachers. "They provide us with important tools, so we are able to take it to a higher level".

## **CONCLUSIONS FROM EXPERIENCES SO FAR FROM THE DEVELOPMENT OF A NEW CDIO BASED EDUCATION PROGRAMME**

Regarding the results from the student interviews, we can only conclude that there is indeed progression throughout the education. The students can see and feel the progression themselves, and we rely on them to inform us of any irregularities, dissatisfactions or good suggestions. It is important once again to stress the significant factor that these are our first students taking the food analysis education, which means that we can learn from them in order to continuously make this education better.

Until now, focus has mostly been on the students, but now we need to focus on the teachers and create a synthesis between the students' and the teachers' understanding of the education. The next activity in the community of practice formed around this new CDIO based education program is a residential meeting that will take place in May 2012. After the first year the students and teachers meet to align expectations from the two groups and to get a common understanding of the whole education as well as a progression of learning and principles of education. The aim of the meeting is hopefully to leave students and teachers with a common goal for future work with the development of the education program.

Another important task for the future development is to involve the Danish food industry in the development of the education. They play an important role as future employers of the students and also in providing a real life context for the students to develop as engineers within. When this first cohort of students reach their fifth semester they will enter the period of internship and this must be aligned with the rest of the education in an effective way.

There is a clear development of the students' understanding of the education and in their perception of themselves as engineers in the Danish food industry. The students' willingness and motivation to take an active part in the development of the education program is a highly valuable source of information about the teaching and assessment methods in the courses. Hence, this contributes to the teacher and teaching development within the program. In this way the community of practice works as a tool mutual to the learning and development of new understandings. In order to gain an even deeper understanding of the teaching and learning activities' impact on students' learning and professional development in the education program, the project will continue and the next step is to make a triangulation investigation with the level of grading. All this will contribute to an ongoing development process in the education of teachers and students and hopefully also provide a deeper understanding of CDIO as a teaching paradigm.

## **BIOGRAPHICAL INFORMATION**

Lars Bogø Jensen is an Associate Professor at the National Food Institute, DTU. He is Head of the Study board at the National Food Institute, DTU and Head of Studies for the Bachelor of Engineering in Food Analysis, as well as coordinator of implementing education in the National Food Institute, a former research institute that merged with the Technical University of Denmark in 2007. He holds an M. Sc. in Chemical Engineering and a PhD in molecular genetics.

Pernille Hammar Andersson is an Educational Consultant at LearningLab DTU at the Technical University of Denmark. She is coordinator and responsible for the compulsory teacher training program at DTU as well as other competence developing activities in teaching and learning. She works with projects aimed at developing teaching and learning at DTU departments, and at DTU in general. She also works with deeper evaluation of new teaching methods and teaching and learning initiatives at DTU. On a national level in Denmark, she is a representative in the steering committee of DACIN, a national network supporting educational development in Danish Engineering Education. Her academic background is in psychology and educational science.

Julie Maria Aagaard is an Educational Coordinator at the National Food Institute at the Technical University of Denmark. Her primary job is to coordinate student relations and support the Head of Studies in developing the educations offered by the department. She is a contact person for the alumni group at DTU, as well as for the Erasmus program, and corresponds on a daily basis with people all over the world who are interested in being affiliated with the National Food Institute, as either a student or an employee. Her background is a Master of Arts in English and Film and Media Studies.

## **CORRESPONDING AUTHOR**

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