

Bridging the Gap between Theory and Praxis in Engineering Education

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ABSTRACT

Previously, most of the students at engineering education programs, had a practical background as craftsmen or similar. They therefore had a frame of reference from their practical work which certainly helped them see the connection between theory and technical systems and constructions which they are working on, and designing. In recent years the number of students with a practical background is reduced to approx. 10 %, and the challenge helping students making the connection between theory and practice through teaching has become greater, as a theory.

Aarhus University School of Engineering has during the past two years participated in a research project together with, among others, Danish School of Education, Aarhus University, with the title *Bridging the Gap between Theory and Practice in Professional Education Programs*¹.

Some of the bachelor programs currently experience a decline in the number of applicants and an increasing drop-out rate. An inadequate theory-practice relation could be one of the causes of these problems, is the thesis of the research project. Many students experience a gap between theory and practice and find 'theories' irrelevant to the development of professional competencies.

The goal of the strategic research project is to generate research-based knowledge about how to develop a fruitful relation between theory and practice in professional education programs.

Four education programs are investigated, including Engineering Education Programs and as one of these, Aarhus University School of Engineering.

This paper deals with the findings from the fieldwork in the research project.

KEYWORDS

The Gap between theory and praxis, CDIO, project work, large classes, examples that support learning.

INTRODUCTION

In the following, my intention is, to describe the preliminary results of a research project that Aarhus University School of Engineering has participated in during the past two years,

¹ <http://www.dpu.dk/brobygning/>

together with, among others, Danish School of Education, Aarhus University, with the title *Bridging the Gap between Theory and Practice in Professional Education Programs*².

The goal of this strategic research project is to generate research-based knowledge about how to develop a fruitful relation between theory and practice in professional education programs. One of the main questions the project should try to answer is:

How can the teaching practice and the organization of professional education be developed to create a more fruitful relationship between theory and practice?

Some bachelor programs currently experience a decline in the number of applicants and an increasing drop-out rate. An inadequate theory-praxis relation is one of the causes of these problems, is one theory. Many students experience a gap between theory and praxis and find 'theories' irrelevant to the development of professional competencies.

In the project we have investigated four bachelor programs, Nurse-, pedagogical-, teacher- and engineering education, to see how the students, the teachers and the leaders all experience the relation between theory and praxis.

The project has covered three phases, each separated in some sub-projects:

The project plan is divided into three phases, as shown in this text box.

<p>Phase 1: Analytical project: Identification of promising strategies</p> <ul style="list-style-type: none">a) Sub-project A: Quantitative studies<ul style="list-style-type: none">i) Identification of institutions with high, low or medium drop-out rates.ii) Identification of factors influencing the connection between theory and practice for different segments of students in different types of professional education programs.iii) Register based analyses of who starts, who drops out, who finds jobs in their profession.b) Sub-project B: Qualitative studies.c) Sub-project C: Systematic review of international research literature. <p>Phase 2: Intervention project</p> <p>Phase 3: Concluding and communicating</p>

Aarhus University School of Engineering has primarily been involved in the *Qualitative studies* and in the *Intervention project* and I will therefore focus on these.

QUALITATIVE STUDIES

The qualitative studies have been analyzing the empirical material from the field work at 8 educational institutes, to of each of the four bachelor programs. At each of the institutions we have been interviewing students, teachers, heads of studies, leaders and supervisors. The interviews have been focusing on primarily how these persons experience the relation between theory and praxis. The main goal was to get to know more about how the students see the relation.

² <http://www.dpu.dk/brobygning/>

In Denmark the students in bachelor programs have periods of internship included in the study. The time schedule for this internship varies from one education program to the other. At the engineering education, which this paper is about, the internship is one half year in 5. or 6. semester. In the other three education programs there is more than one period of internship along the study period.

We have arranged the interviews, so that they took place before, during and after the first internship period. The reason for this was that we wanted to observe and experience how the students think about what theories are used and if theories taught in the school can be used at all in the profession. The reason why we planned with the first period was that this is where students normally drop out.

The very important thing to find out in the research project is how these internship periods are arranged in the education programs.

- How does the supervisors relate school work to internship praxis
- How does the workplace integrate theory to the work that has to be done
- Do the employees at the workplaces know what is going on at the colleges
- Etc.

The main goal of making these internships is to bring what taught in college (theory among others) in action in the workplaces. We are in the research project looking after; does this happen, and if, how.

Or with other words, this *shift in place between college and workplace* and *shift between theory and praxis*, does that work all right, does it increase the students' experience of a good relation between theory and praxis?

The Field Work

In the engineering part of the field work we have been to researchers in the field making observations and interviews.

We have made following interviews in the engineering part of the project:

- Institution A.
 - o Nine interviews with five students
 - o One focus group interview
 - o Three interviews with teachers and supervisors
- Institution B.
 - o Nine interviews with six students
 - o Four interviews with teachers and supervisors

In the original plan we wanted to interview the students also at the workplace as they were in the internship period. This failed; we did only get one interview at the workplace, with two students in the same workplace.

About the Students interviewed

The students interviewed in the engineering educations where mostly on the 5. – 6. Semester, as this is where the internship is placed.

At the institution A. though, we have interviewed students in 4. semester. These students were in a special educational program, with so called mentor internship. In this program the students are in a mentor-workplace 7 weeks every semester. This is a new design of the program to improve the relation between theory and praxis, and it seems to work.

The students were from four different studies, Global Management and Manufacturing, Mechanical Engineering (mechatronics), Electronic Design Engineering and Interaction Design Engineering.

The 11 students were distributed as three female and eight male students. This are also approximately as the distribution are at the engineering educations in general.

Results from the Qualitative Studies

The project is running until summer 2013, these results are therefore primary results as they were presented at the midterm conference September 2011.

We found that there were big differences between the educational programs in the project. Especially the engineering education programs differed from the others, in more ways:

- The internship is placed late in the study. It is more than trying out what is learned at the college a kind of preparation to the labor market.
- Where the other educations are distinguish between praxis as what is happening in the internship periods and theory at the college, the engineering educations are working very praxis oriented all the time in the study period.
- The engineering candidates mostly get jobs in the private industry and the other mostly public workplaces.
- The engineering educations are based on a natural scientific learning tradition, where praxis is based on theory more or less
- We are working with technique, function and design, where the relation between theory and praxis might be more natural.

Regarding the gap between theory and praxis, we found in the engineering educations:

- We have generally found some very practical and vocational education, where the gap between theory and practice is not perceived as particularly problematic. The students are aware of what theory is and what praxis is, but it seems that they do not see a gap or any problem in this two different and separated things.
- Among the interviewed students, we found no significant difference in their understanding of the theory - practice during their shift between educational and internship
- Praxis is involved in education in many ways and at all levels, in fact, it appears that students from the start of the study in a sense, working as an engineer
- Practice is part of the study from the first semester

We also observed how theory and praxis are connected in the engineering educations:

- Here the students make experiments, build prototypes, etc. Workshop and laboratories are merging on the same physical location
- Practical experience in the school is attached to the subsequent employment. There will be change in jobs frequently and skills used in other industries, there is a visible career path
- Here work is problem-based; the problem is often formulated in collaboration with a company, thus granting the case of a *real problem*. The company has ownership of the project and often is made a confidentiality contract. *Experts in teams*: an example, how an interdisciplinary cooperation in business between different disciplines on a real problem.

- The student is in the internship period employed for a period of six months, with pay. Working as an engineer (foal). There is socialization into the engineering field.
- During the periods where students staying in the engineering college, they are working on projects that are formulated in a collaboration between the school and the company. Work is continuing on the job / project in the classroom, the theory attached to the work experienced in the workplace.
- The students are in some way in the hole study period working more or less as an engineer

What has been done not that good and can be improved:

- It seems like the experiences from the internship period are not activated in the following study period
- The students says, that they do not get the personal competencies they need to go into the workplace or profession afterwards
- It seems the teachers do not talk much about pedagogy and the personal skills is not articulated
- It is a challenge making the teaching of mathematics for example more praxis-oriented, here is to improve consistency.

What one student says about theory and praxis; citations (translated), Q is interviewer:

Q: *How is your normal day, what is going on (in the first semesters)?*

C: *"We have had some theory in the morning and then praxis after lunch"....."Theory is what goes on in classes, and then after lunch....all teachers are available, so we could contact them for help. There we could work with project work, exercises, assignments or what was relevant"..."else we had project-lab and el-lab, where we could...."*

Q: *What do you do in there?*

C: *"Well, there we are... playing with 'boards'..... soldering things together, and what else could be, and measuring on things. Once we made an amplifier."*

Q: *Did that relate to some of the theory lessons you have had?*

C: *"Yes"*

In general we observed that the students see theory as what goes on in classes and praxis as what goes on in lab, exercises, building prototypes, assignments, etc.

INTERVENTION PROJECT

The intervention part of the research project is meant to try some of ideas created in the Qualitative Studies out. Because of the time schedule the plan changed, so that this 3. Part of the project more became a series of projects showing what has been done in the four education programs to improve the relation between theory and praxis.

Intervention Project in the Engineering Education

In the engineering education program the project was to show how CDIO is a framework that is meant exactly to do this, improve the relation between theory and praxis.

The project took place at Aarhus University School of Engineering and was formed out in following way:

- Interviews with 4 project groups on different semester and studies
- Interview with a group of teachers/supervisor
- Interview with a group of leaders (that has been involved in implementation of CDIO at the school)

- An anthropologist has followed a class in a week in both classes and project work
The project took place in spring 2011, running over two weeks.

The following general questions were asked:

- How can CDIO create coherence between theory and practice?
- What is it in the CDIO model that helps to create coherence?
- What do educators think about CDIO, how do they use it, how do they use it to create coherence between theory and practice?
- What is definition of theory and practice, seen from the students' perspective, why do students not know anything about CDIO and does it matter?

Some key findings in the intervention project (CDIO)

- It was very clear in the interviews that nearly all the students had never heard about CDIO, but when interviewed about how they worked with their project work it was also clear that they did work according to the four CDIO-phases. It is just how engineers and engineering students work!
- A couple of citations that tells how the students see it:
 - Kurt: *"We would rather sit down and design something and dimension and so on and so do it. Just like with the screws we had hold of - those, we also did practical tests with a tensile testing machine and measured how much was needed to pull them to pieces. And in the first semester when we made it there motorcycle lift that we built it also purely practical. So we were in the workshop and welding and screwing and cutting and ... [...] we raised - we made it and we raised a motorcycle with it. So you feel like that, theoretically, two points below, and practical: two lines below. And I think that is satisfactory compared to just deliver a project on paper. "*
 - Mads: *"This is what is to be a part of a process ... and then to follow it through to the end. It is with that you just start with nothing, and when you're done ... there's something that people can use for anything.*
- It was obvious that CDIO improves the relation between theory and praxis, but it was also clear to us that it was not like a revolution implemented at the school. It was also earlier how we worked.
- CDIO was described more as a framework than a new way to work. A citation that tells how a teacher see it:
 - Søren: *You try to do our education program application-oriented and I think actually that we have done so for many years and I do not think so necessarily that I would ascribe CDIO ... But I see it is that we have got a better visualization of things by that we have some interpersonal and some professional and other things so you could say that one becomes aware of - you have a shared understanding of some things when we talk together - studio management and trainers, and educators*
- It is a challenge to assess the personal and interpersonal competences. So even though it is formulated in the learning objectives it is not sure that it is learned.
- It might be a problem that the model has not been visualized to the students. They have been taught according to a model they do not know.
- It still is a challenge to implement CDIO in the teaching in the class-rooms, especially big classes.

How can CDIO be implemented in the other educational programs?

It might be possible to use the model in then other programs, but it is then maybe necessary to implement also more praxis oriented teaching and project work.

You could say, they will have to work all the way through the study in the same way as they are doing in the profession, not only in the periods at the workplaces but also in the school periods. This would be one path to take, if the goal is to improve the relation between theory and praxis.

But I am aware of that there are other agendas also. Such as the formation aspect, learning theoretical methods, just to mention a couple.

CONCLUSIONS

We, ASE, are not normally involved in research projects as this, so what can we learn from it?

One main question was:

How can the teaching practice and the organization of professional education be developed to create a more fruitful relationship between theory and practice? So that drop out can be avoided and we get better candidates.

Out of the four programs studied the engineering educations experienced the least problems with the gap between theory and practice, actually some of the conclusions of the project mid-term conference, were the following;

- We have generally identified some very practice-oriented and vocational educations, where the gap between theory and practice is not perceived as particularly problematic
- Among the students interviewed, we found no significant difference in their understanding of theory - practice during their shifts between education and internship.
- Practice is involved in the educations in many ways and at all levels, in fact, it seems that students from the start of the study in a sense, are working as engineers
- Practice is part of the study from the first semester

One of the sub-projects of the research is to test some of the efforts made to minimize the gap between theory and practice. Here the CDIO engineering education model was the subject of study.

In brief some of the key findings in the CDIO-intervention project are:

- Students in the project teams had not heard anything about the CDIO model before, but even so the explanations of project work stages actually fit exactly in the four phases. This is a verification of the fact, that it is an accepted way of working as an engineer in a development project. In this way it also helps to create links between the theory taught and the reality they will later be confronted with in “the real world” (practice).
- In some of the theoretical courses, which typically runs parallel to the project work, too little praxis is involved and insufficient correlation between the project and theory courses are established.

One of the conclusions which we can learn from the research project is exactly, to work on improving the relationship between theoretical courses and project work. The challenges here are many:

- How to implement practical examples in theory-classes, when it takes place in an auditorium or large classrooms with cinema setup?.

- How to work with practical experiments with large classes and many groups without working with cooking book exercises?
- How to select the good practical experiments that support the theory of teaching in the best way?
- Etc.

KEYWORDS

Energy and system design, prototypes, project work, thermodynamic, control-and simulation of dynamic systems.

REFERENCES

Reference is made to the project description, <http://www.dpu.dk/brobygning/omprojektet/>

Biographical Information

Aage Birckjær Lauritsen is an associate professor at Aarhus University School of Engineering. In half of his work time, he teaches mechanical engineering-students in the field of thermodynamics, fluid mechanics, and centrifugal pumps etc. He has a nearly 30 years of experience in teaching.

In the other half of his work time, he is working in the CDIO Development Lab at Aarhus University School of Engineering, developing work for younger and older colleges. He also teaches younger colleges to teach at a so called “adjunct”-course.

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