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Kolmos, Anette

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Transformation to Problem and Project Based Learning

Anette Kolmos

During the last ten years, Engineering Education has undergone tremendous changes. A lot of these changes were caused by external and internal factors. The external factors such as government policy concerning resources, and educational and quality assurance policies are rather simple to describe. However, the internal factors at the institutional level may be unknown. Institutions have developed many different pedagogical models, using very different strategies for development.

Nearly all Danish engineering institutions have implemented elements of Problem Based and Project Based Learning (PBL). Particularly five Engineering University Colleges have undergone changes towards PBL. The Pedagogical Network for Danish Engineering Education (IPN) has been one of the central agents in the change processes for engineering education in Denmark. IPN has been responsible for staff and faculty development at the engineering university colleges and has been running the co-ordination of the exchange of experiences among all Danish engineering institutions.

However, it is not the same PBL-model that has been developed at the five different institutions – in fact, very different PBL-models have been developed on the basis of very different development processes.

In this article, I will shortly present the results from two case studies. The results underpin the hypothesis that only top-down decisions at institutional level together with a pool of motivated staff will cause changes at a system level. A bottom-up approach with decentralized development at departments leads to a variation within the institution, but it might be difficult to develop curriculum models at system level.

Introduction

Change in higher education is not a very well-described area. Fullan (2001, 2004, 2005) is one of the few authors who have developed concepts for change in education – primarily based on experience from primary and secondary school. He emphasizes that the outcome is not only student

learning, but also organizational capacity. Students leave the education – the sustainable factor is that the staff has changed in order to constantly develop students' learning and the learning outcomes. Fullan stresses that change is a process, not an event (Fullan, 2001, 2005), and this means that change is not something that can be done overnight. It takes time and it reaches into values and conceptual change (Henriksen et al. 2004).

In order to find a concept of processes of change, one often has to turn to organizational literature, and in that connection, Kotter is frequently drawn upon. Kotter's (1995) model for change is often used to illustrate phases at a more specific level. This model was developed in the context of companies, but has been used as an analytical model for education processes as well (Morgan and Roberts, 2002). Kotter (1995) works with eight phases, see figure 1.

The important aspect of Kotter's eight phases is that he stresses the importance of urgency and the creation of visions. In our experience as faculty developers who are often given workshops on various education topics and with the purpose of motivating staff, staffs do not possess the sense of urgency nor feel that they have a part in formulating visions.

Figure 1: Kotter's eight phases

Phases	
1	Establishing a Sense of Urgency
2	Forming a Powerful Guiding Coalition
3	Creating a Vision
4	Communicating the Vision
5	Empowering Others to Act on the Vision
6	Planning for and Creating Short-Term Wins
7	Consolidating Improvements and Producing Still More Change
8	Institutionalizing New Approaches

Normally, teachers do not experience any urgency – on the contrary, they feel confident and satisfied with existing teaching practices. Only few staff members feel the need for change. External reasons are most often the trigger of internal institutional change.

In Kotter's version, the vision consists of the leader formulating and communicating the vision to the staff. In educational settings, the role of the leader might be hard to define and fulfil as leaders often are very good colleagues with "their" employees. So the formulation of visions has to be regarded as a common process among colleagues. The vision element is important since the process of visions may include both motivation and an overview of the total planning process (Moesby, 2004).

Change in higher education is much more complicated compared to change in private companies due to the organizational structures and, not least, the role of leadership. In private companies, leaders normally have the power to direct and control initiatives. In higher education, leaders are

normally elected among colleagues and leadership has a tendency to involve administration rather than pointing out future directions. New trends are emerging with appointed leaders in higher education; however, the impact on change is still to be investigated.

Regardless of appointed or elected leaders, Kolmos, Gynnild and Roxå (2004) make the point that all levels in the organization get involved if the organization enters a change process. Bottom-up strategies are not efficient because change at system level requires a decision at top-level. Similarly, top-down strategies are not efficient because they create a lot of resistance in the system. So the optimum situation is to establish change by using both top-down and bottom-up strategies – and research shows that both strategies are needed.

There is a need for change agents – if the change starts from the top, change agents must be found among involved staff members, and if the change starts from the bottom, change agents must be found in the top. The role of change agents is to motivate staff and to lead the change process by pushing the whole time. Pushing for visions – pushing for exact plans – pushing for resources, strategies, etc. We are not saying that each individual change agent should cover all the responsibilities, but experience shows that there must be some drivers (Kolmos, 2002).

There is also a need for faculty development units – and for these units to relate to all levels in the organization - both the top, middle, and bottom levels. However, in order to develop that kind of practice, resources and awareness are needed. Faculty development units can be change agents as well on the general level, but normally they do not have the subject knowledge.

The Two Cases

Over the course of the past 30 years, a number of radical changes have taken place in Danish engineering education. What is unique about Danish engineering educations is that not only one individual institution, but all institutions over the last ten years have developed their teaching on the basis of student-centred conceptions of learning. We have witnessed an emerging tendency to formulating models and systems, albeit of very different nature. All institutions employ project work of some sort, but the practical implementation and scale of it vary.

Overall, all institutions have been guarded by the same educational-political processes, which are characterized by:

- Transition from technical college to engineering college.
- Continuous cutbacks.
- Merging of institutions.
- Change in organizational conditions from democratically elected structures to hired leaders.
- Introduction of interdisciplinary projects in the 1980s, which has earned the institutions their first project experiences.
- Need for upgrading skills in order to elevate professors to Master levels.
- Joint pedagogical skill development through the establishment of the Pedagogical Network for Danish Engineering Education.

The two institutions where the processes of change have been analyzed are in many ways similar.

- CASE A
- University college
- ~ 1050 students
- ~ 100 staff members
- institutional change in 1998

- CASE B
- University college
- ~ 950 students
- ~ 95 staff members
- Institutional change in 2002

At both institutions, eleven interviews were conducted with former and existing leaders and teachers.

Case A

Wide-scale project work was introduced at a time when there was still a democratically elected direction. This has a great influence on the process since that type of structure entails limits to how much the direction can manage the process without clear support from the staff. Consequently, interviews with employees at this institution also reflect that they do not remember there being any great resistance to the changes because these were supported by the employees' decisions. However, a few of the employees would have liked to carry through more radical solutions.

Figure 2: Case A - model

Semester 1-4	Course 5ECTS	Course 5ECTS	Course 5ECTS	Course 5ECTS	Project 10 ECTS
Semester 5	Practicum				
Semester 6	Course 5ECTS	Course 5ECTS	Course 5ECTS	Course 5ECTS	Course and pre project 10 ECTS
Semester 7	Course 5ECTS	Course 5ECTS	Project 20 ECTS		

Total 210 ECTS (European Credit Transfer System, 1 ECTS=30 hours of students' work):

30 ECTS for practicum
70 ECTS for projects
110 for traditional courses

The model can be described as below. A characteristic feature is the fact that no major merging of courses occurs. A project worth 10 ECTS is introduced, though, on each of the semester 1-4 and 6, and a project worth 20 ECTS on the last semester.

Described in facts, the process of change was as follows:

- 1996-98: they joined several workshops held by IPN on project based learning. Many teachers tried to experiment with project work.
- 1998/99: decision made stipulating that at least 1/3 of the overall time should be used for project work. The decision was made by the senate, which at that time was a democratic forum elected among staff members.
- 1998: rebuilding of the physical infrastructure to allow for groups rooms.
- The internal staff development function was not well-established at the institution – there were only very sporadic, if any, follow-ups after the first workshops in 1996-98.
- The interviewees could not remember any resistance among colleagues.
- No sure indications that the approach to teaching and learning had changed. Projects are mainly regarded as application of the knowledge that has been taught in lectures.

Compared to Case B, the interviewees did not express any particular excitement about their change. This could be ascribed to several factors, for instance, the fact that a substantial time had passed since the change occurred and therefore, perhaps, they were unable to remember it in detail. But it also has to do with this institution having undergone a process of change initiated by a newly hired leader, who did not find the employees of the institutions properly prepared for the new changes.

Case B

At institution B, the changes were implemented at a later stage when it had become managed by a hired direction. The leader who was hired came from the department where project work was carried out already in the mid-90s. With the elected direction it was chosen by the direction that a reform was to be implemented, and direction set up a committee to lead this work. The model can be described as below, figure 3. A characteristic feature of this process was the fact that smaller courses were grouped together in bigger professional units.

The process can be described as follows:

- 1996-2000: several training workshops on project work were held.
- Late 90s: electronics and mechanics started to implement elements of PBL - but very different approaches to it. Electronics had some very enthusiastic staff members. The other department did not have PBL to the same degree as Electronics.
- 2001: new leader was appointed – he came from electronics.
- 2002: cuts in resources - decision was made to develop a model – very much based on the experiences from electronics. Group rooms were build.

- The decision was a top-down decision – and a group of change agents were pointed out to lead the actual transformation process.
- There was a strong internal staff development unit to support the idea.

The process of change in institution B involved additional elements. In part, new goals for development of students' process competencies were formulated in connection with the introduction of project work. In part, experiments were carried out involving the use of formative assessment methods in courses, and, not least, experiments concerning the timing of the relationship between courses and project.

Figure 3: Case B - model

Semester 1-4	Course	Course	Project 10 ECTS pr. semester
Semester 5	Course	Course	Project 20 ECTS
Semester 6	practicum		
Semester 7	Project normally with a company 30 ECTS		

Total 210 ECTS: (European Credit Transfer System, 1 ECTS=30 hours of students' work):

30 ECTS for practicum
90 ECTS for projects
90 for traditional courses

Finally, the committee in charge of the process of change formulated a number of visions, philosophies, and values to accompany the new models.

The interviews demonstrated that the interviewees were incredibly proud of their process of change. They held their own understanding of the model and the underlying pedagogical concept. At first, this phenomenon occasioned a great deal of reflection on the interviewers' parts, but along the way, this came to be interpreted as a positive expression of the personal internalization of the pedagogical processes of development.

Institution B also experienced resistance - around 20% of the interviewees from this institution did not wish their interviews to be recorded – but they clearly expressed that they "just did as they had always done, only now it was called something new, but in reality it was not new at all." To questions of why they kept doing like they used to, the typical reply was "that the students are unable to learn this profession in any other ways."

Institution B is well aware of the resistance – and has chosen to ignore it this time around. As long as this does not cause any student complaints, the direction will disregard it. But at some point, it will be dealt with.

Comparison and Perspectivizing of the Two Cases

A process of change is not initiated without the presence of external causes. External causes have influenced both institutions, albeit at different points in time. Extensive institutional changes rarely occur without an external pressure since many resources are involved.

The two institutions have had very similar conditions of change, but the processes of change have taken place at very different times and under different managerial structures. At institution A, change took place under a democratically elected direction that has had no intention of causing division in the organization, but instead has set realistic goals for the processes of change. This way, they witnessed a bottom-up approach that led to a managerial decision on top-level. However, we here see a model that is not far-reaching in its endeavours to implement a different pedagogy. The institution still holds a series of individual courses with individual exams and no attempt to integrate courses and project.

Institution B has, in the case of one department, had a pattern similar to that of institution A. Institution B consists of two departments, one of which already in the mid-90s reorganized the educations to contain project work, whereas the other department has had much more sporadic experiences with project work. When a new direction was being hired, the direction became dominated by people from the department that already had adopted the project work, and it was agreed that the entire institution was to develop a common model for teaching. Here, we are dealing with a bottom-up approach since one department already has set out the course, but simultaneously, with a top-down approach as the newly hired direction makes the decision to make it apply to the entire institution. If a democratic process had been allowed to be the basis for decisions in the department that had not adopted PBL, the decision to implement the model might not have been as far-reaching.

Both cases demonstrate that only top-down decisions at institutional level together with a pool of motivated staff will cause changes at a system level. A bottom-up approach with decentralized development at departments leads to a variation within the institution, but it might be difficult to develop curriculum models at system level without the top-down decision. For universities in some countries, this conclusion might seem banal – but in an European context, this is a very important result.

Figure 4: Change processes

Phases	Kotter, 1995	Case A	Case B
1	Establishing a Sense of Urgency	External reasons Cuts in resources	
2	Forming a Powerful Guiding Coalition	No	yes
3	Creating a Vision	Absence	There is a process of formulation visions – but not all staff members participate
4	Communicating the Vision		
5	Empowering Others to Act on the Vision		
6	Planning for and Creating Short Term Wins	yes	yes
7	Consolidating Improvements and Producing Still More Change	There is a tendency to stop	
8	Institutionalizing New Approaches	This has been done at both institutions	

Institution B also managed to develop a more holistically coherent education. Through the process of change, the institution succeeded in getting a more qualified staff to have a vision for their own processes of change. This does not include all staff members, however, since approximately 20% of them are very negative towards the changes that have taken place.

Looking at the results from the two cases in terms of Kotter's eight phases, see figure 4, more effort and attention could definitely have been devoted to two phases. Phase 1 involves a sense of urgency, and no one in either institution really feels this. Most see the changes as being necessary because of financial reasons and not because the students are to learn new and different competences. Even though in institution B there has been talk of formulating new competences, the need for this has not been the guiding factor for the individual employee. The common perception was that it was simply necessary to do.

No vision has been formulated at institution A as there has at institution B – even though everyone has not taken part in that process. But both institutions tend to stop the process of change – no new energizers enter the process. Nonetheless, it is important to conclude that both institutions have developed models, and they have succeeded in institutionalizing the changes by, for instance, altering the physical infrastructure.

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