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Continuing Engineering Education: a New Task for Universities in Denmark

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Engineering competence is a major competitive parameter in the knowledge society, especially in an industry that is subject to very fast innovation processes. New products and production processes are knowledge-based and one has to focus on the importance of human resources as a significant asset for industrial development in order to be a step ahead of competitors. Continuing Professional Development (CPD) of engineering personnel is therefore very important. In Denmark there has been no established tradition for universities to be active in continuing education. As such, in 2001, the Danish Ministry of Education esatblished and funded a group of competence development centres at six universities. One of these is the ELITE (Elektronik og IT Efteruddannelse) Centre at Aalborg University, Aalborg. The ELITE Centre researches CPD and the article presents some of the ideas behind this. Research results concerning the modelling of the CPD context and the development of new methods for the system of university facilitation of competence development in industry are also presented and discussed in the paper.

INTRODUCTION

Over the last decade, knowledge and competence have become two of the most competitive parameters in modern society. Engineers must always be *one step ahead* of their competitors in their efforts to integrate new knowledge into their products so as to maintain a competitive advantage. The Continuing Professional Development (CPD) of engineers has become increasingly vital for this reason.

CPD includes the development of professional theoretical skills, in addition to the practical work functions, ie a combination of continuing engineering education along with productive engineering. Thus, there is increased focus on the importance of human resources as a significant factor for industrial development.

Denmark is perhaps still known as a country with farming as the main industry, yet this is no longer the case. Some three decades ago, Denmark was also a nation with a large fishing industry and a major fishing fleet. The Danes had some extensive and modern shipbuilding yards, but this industry is also almost gone. In this part of the world, the unskilled labour force is relatively expensive and, as there are no natural resources, Denmark does not have many, nor indeed big, industrial production companies, of course with a few internationally well known exceptions, such as Danfoss Grundfos, Bang & Olufsen, to mention a few.

However, these exceptions are not enterprises that are based purely on production, although their products can be characterised by their high quality standards and their unique engineering developments and designs.

A trend evidenced in Danish industry is that there is an increasing amount of resources that are being invested in product development and in the quality of those products, in particular. More and more companies are purely or mainly based on product development, ie companies where the majority of staff are engineers. There is also a tendency towards an increasing number of companies being established on the basis of an innovative idea, but with such enterpises later being integrated into an international group.

One method for major foreign companies to establish themselves in Denmark and to gain access to Danish competences is for international groups to take over Danish companies.

COMPETENCE AND HUMAN CAPITAL

As stated already, the main natural resource in Denmark is human capital. As such, well-trained workers and well-educated engineers are a basic asset in Danish industry. Continuing Professional Development is therefore a prerequisite for the survival of the Danish economy.

There are fast innovative changes within the industrial context, and the planning of professional development activities must therefore be highly dynamic in order to accommodate these processes and cannot be rigidly scheduled. Furthermore, the framework for professional development courses must include fast and continuous follow-ups on those needs identified by the industrial organisation in order to ensure that engineers continuously advance the knowledge and skills necessary to attain their goals.

CPD COURSE PROVIDERS

The task of supplying innovative continuing educational programmes to engineers is a very professional and demanding task. Educators must have opportunities for fast and easy access to new knowledge, engineering tools and applications.

For several years now, continuing engineering courses have been offered by private organisations, including the Danish Engineering Association for Continuing Education (DIEU) or the Danish Technological Institute (DTI). Such organisations provide courses, partly based on their own experts, and partly on experts from universities and other research organisations.

There is a tendency for these course providers to move into the field of Information Technology (IT), software development, personal training and management. This leaves an open question: where does a Danish company or Danish engineer find a top level, hard core, technical course? They can go abroad to follow courses given on different sites in Europe, or they can seek such courses to be given as onsite plant courses in Denmark.

THE ELITE: A CENTRE FOR CONTINUING ENGINEERING EDUCATION AT AALBORG UNIVERSITY

Modern companies, including Small and Medium size Enterprises (SMEs), basically compete on the basis of having the best employees with the highest levels of education and competence who can keep abreast of new developments. There must be a significant replacement of existing staff with those more competent, or a continuous investment in the maintenance and expansion of the organisation's total competence in order to maintain a competitive level in production, and sufficient flexibility so that companies can quickly adapt to heavy knowledge demands.

This competence has to be maintained and developed continuously by both the company and the individual employees. New research results must be integrated into product development as quickly as possible. Therefore, a model is needed for the rapid transfer of knowledge to industry that results from research achievements. Technical staff members have to develop professionally on a continual basis, eg by taking part in appropriate learning processes such as life-long learning.

SMEs have the same needs as larger companies. However, because of their smaller size, it is even more important that employees attend their jobs. Leaving their jobs to engage in a professional development programme is neither feasible, nor necessarily advisable; SMEs are especially vulnerable when individuals are absent.

Given this background, a two-year research project (PRO-ACTT), which was supported by the European Union (EU), on the modelling of the context of Continuing Professional Development was carried out under the leadership of Aalborg University (AAU), Aalborg, Denmark [1][2]. Some of the results with regard to industry-university cooperation and modelling of the context of CPD are described and discussed later in this paper.

As a continuation of PRO-ACTT, and based on the experiences from this project, a competence centre for continuing engineering education in electronics and information technology, entitled ELITE (Elektronik og IT Efteruddannelse), was established at the AAU [3]. The ELITE Centre offers:

- Short courses;
- Courses-on-demand;
- Two-year part-time programmes;
- Courses offered onsite at enterprises;
- Courses with foreign experts;
- Web-based courses or programmes;
- Work-Based Learning;
- Networking for human resource managers;
- Panels for decision makers from the industry.

The experience gained thus far is not to focus too much on, for instance, two-year programmes. Busy engineers in the electronics and IT business cannot foresee how their situation will be in a two-year period and part-time (say 50%) programmes will be too heavy a burden for them. Therefore, the focus is

on short courses, courses on demand and on making the ELITE more visible. Most importantly, the target is to meet the busy engineer in his/her daily task and integrate the learning process into the job function. The ELITE utilises Work-Based Learning (WBL) in order to map its experiences from Problem-Based Learning (PBL) into an industrial context [4][5].

The following section describes some important elements that are a prerequisite for successful CPD.

UNDERSTANDING THE CONTEXT OF CONTINUING ENGINEERING EDUCATION

The exchange of information between a university and a company is critical in the establishment of an effective framework for professional development.

The first attempt in devising a model for organising professional development between a company and a university is explained elsewhere [6][7]. The constructed model comprises eight elements that are based on the background of research and development within didactic and organisational learning. All of the elements and their unique characters play a role in a flexible continuing education process.

The organisational relationship between companies and universities, the different strategies of companies and universities regarding continuing education, and, especially, the goals and contents of professional development, are of a more cultural and societal character than are the other elements. However, it is the relationship between all of the elements that is of decisive importance to the actual arrangements.

The primary element concerns the process, goals and content of professional development. Particular questions must be answered regarding the level of cooperation between the university and the company, and cover specific types and levels of technical and knowledge-based needs. Special attention should also be given to the technological capacity of the society in which the company is based, as these needs may vary greatly across countries and individual companies. These factors related to those elements in the model will significantly influence the selection of a strategy in carrying out the needs analysis.

Figure 1 shows the revised model that has been developed based on experience and utilising the relatively complex model by Fink and Kolmos [6]. This is described in more detail elsewhere [7].

CONTINUING PROFESSIONAL DEVELOPMENT AS A UNIVERSITY ACTIVITY

The field of continuing engineering education is still relatively new to universities, and programmes in this area may not yet be integrated into the university's educational and administrative practices. It is important to consider *why* university educators should be involved in this activity, *what* will be the goals to achieve and *how* it must be implemented.

With respect to the university, there are several *system issues* that need to be resolved before implementing a continuing education programme. It is quite possible that those universities seeking to integrate continuing education programmes into their system will encounter resistance from academic staff.

State universities, like those in Denmark, are economically controlled by very strict rules. These

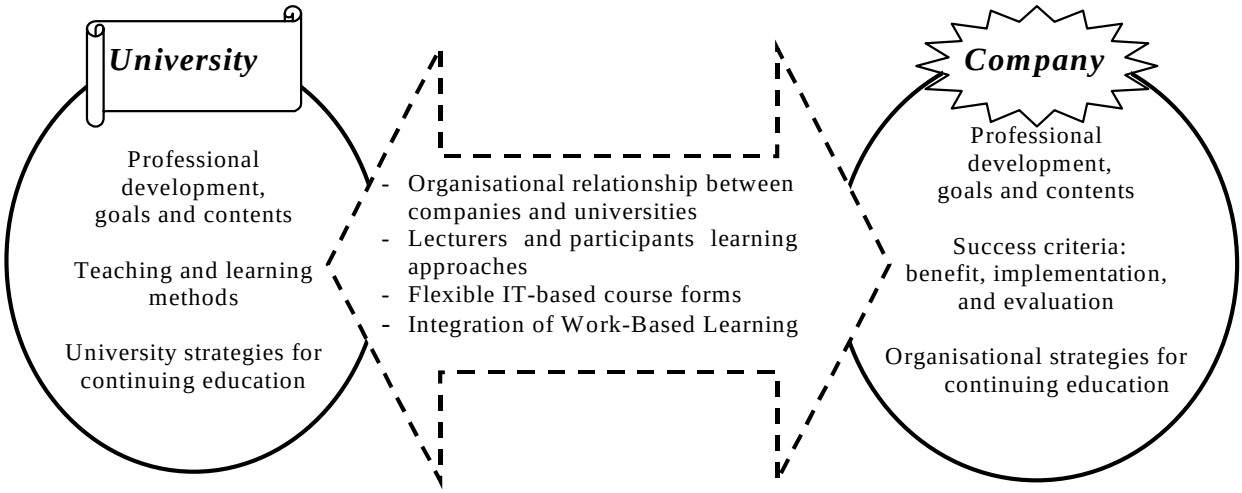

Figure 1: A revised model for Continuing Professional Development (CPD).

regulations seldom work cohesively with activities of a more commercial character.

Industrial engineering is application-oriented and it may be difficult to adapt professors, who are normally engaged in fundamental research, to the needs of industry. Those universities with more application-oriented research, including cooperative research with industrial partners, will be better prepared for educational activities that are applied to the needs of industry.

The dynamic nature of continuing education may also present an obstacle for the adoption of such programmes because the university culture is usually based on rigid planning and clear administrative practices that are not applicable in this case. The university must be prepared to offer courses *on demand* rather than according to a rigid and predetermined schedule. Furthermore, flexibility in terms of class size, content and scheduling will make the allocation of additional human resources necessary in order to prevent overburdening existing lecturers.

TEACHING AND LEARNING METHODS

Basically, there are two broad types of teaching and learning methods from which the company may select: *company-oriented* or *university-oriented* methods and approaches.

Company-oriented methods and approaches may vary according to the structure and strategic decisions, such as:

- Just-In-Time (JIT) courses or courses on demand, in which the company defines its actual needs for knowledge development and the university quickly plans special courses to satisfy these needs.
- Those project forms that may be characterised as a cooperative agreement between the university and the company (development departments) to have university researchers participate in development teams and to incorporate Work-Based Learning.
- Part-time programmes (ie courses or projects) implemented as IT-based distance education (flexible in time and place).
- Work-Based Learning with professors facilitating the learning process and integrated in normal productive engineering practice [5].

On the other hand, the concept of *university-oriented* methods and approaches can be considered in terms of ready-made courses within given subject areas. These courses may be offered to both the individual company as onsite courses or to groups of companies with individual enrolments.

At a more specific level, the choice of which particular teaching methods are to be used is also important. Again, the relationship between the company and the aims of the competence improvements plays a vital role, as more participation-oriented and interactive methods and approaches can be linked to internal company work. Integrating formal engineering education and productive engineering creates a new challenge that can be met, as a result of many years of experience with Problem-Based Learning (PBL) [4][5].

Continuing Professional Development as a Company Task

The industrial organisation must realise the need to have access to the research-based knowledge that is present at universities to realise the goals that can be achieved.

Consideration must be given to the means utilised in applying the learned knowledge and skills in the company. The integration of recently learned professional skills should serve as an important criterion for the success of the development process. Because the needs and values of organisations will most certainly vary in nature, it is imperative that the individual organisation explicitly describes the specific criteria that will be used to evaluate their own professional development process.

The goals should be presented as specifically as possible and be part of a mutual agreement between the university and the company. The company should take an active part in formulating the goals and success criteria. Experiences from numerous continuing education courses indicate that it is quite often the absence of such formulations of success criteria that results in an ambiguous and ineffective evaluation of the completed courses.

Companies differ in their awareness of the importance of the professional development of engineering staff. The demands placed on skilled engineering staff increase in parallel with the growing number of consumer products, industrial equipment, etc, that include more advanced functionalities and features. Strategies will differ between companies in order to meet these requirements. Internal organisational strategies for continuing education play an important role in the planning of continuing education courses.

Organisational strategies may vary greatly from *total strategic planning* for the company, where a

basic education course plan is established for a number of employees, to *individual employee strategies*, where employees select their own continuing education courses. Individual employee strategies do not need to match the choices of their colleagues.

Strategies for professional development in a company will often fall somewhere between these two extremes. It is also quite possible that the company may adopt a *laissez-faire* attitude by never fully formulating a strategy. In any case, the strategy that the company selects will greatly influence the formulation of professional goals, success criteria and the nature of cooperation, as well as the interaction between the university and the company, during the developmental processes. The most important aspect in selecting a particular strategy (or combination of strategies) is that the professional needs and goals of the organisation can be met, and that the strategy reflects the dynamic industrial environment in which the engineers function in the best possible way.

Based on several years of dialogue with industry concerning engineering staff development, these strategies can be divided into different idealised categories [5].

CONTINUING PROFESSIONAL DEVELOPMENT AS COOPERATIVE PROGRAMMES

Most private professional organisations offer courses for engineering professionals to update their skills. These are organised as onsite courses or intensive courses in nice locations or major international cities, etc. Such courses, whether they be upgrading, re-education or just follow-up, take time.

Most innovative companies are aware of the importance of improving professional competence. It is known from CPD contextual research that even though professional development is identified as vital for the future of the company, individual engineering staff members must often find the time for such courses themselves [6]. Furthermore, such programmes are not integrated into the time-plan for the project. Money for financing the course is normally no problem, but *time* is.

Another parameter to be considered is the recognition of the course as being part of the individual curriculum; this means that some kind of standardised approval is desirable. As such, CPD programmes must be developed to meet the expectations of both the managers, as well as the engineers. CPD programmes need to integrate new academic knowledge into the productive daily process of the engineer and vice versa.

Part-time Master Programmes

The AAU has implemented some specific Master programmes as research-based PBL activities [5]. These Master programmes are 1-1½ year programmes on a half-time basis, which means that it takes two to three years to complete them successfully . The programme consists of courses and project work and, as in standard daytime studies, the project must involve at least 50% of the time and some of the courses must be incorporated in the project.

This programme is organised thematically, that is it should be possible for those engineers attending the programme to integrate their job tasks into the study programme via the project, or to integrate the application of the courses into job tasks. In this way, the study workload will be considerably reduced. Previously, Aalborg University only encouraged the engineer to integrate study and work, although it was realised that this was not always easy. In the future, Aalborg University will consider new ways of more direct cooperation between university and company at the management level so as to define the framework of the educational process.

IT-based distance education is very important in these Master programmes [8][9]. Distance education tools are being utilised in the courses, as well as in the dialogue between students, dialogue between students and teachers, development in the project work, etc. This means, for example, that even though an engineer is posted to work in another country for a period of time, he/she can still be an active student. However, face-to-face seminars are still important when ever and where ever possible. The AAU tends to schedule seven to eight two-day seminars a year at the University (or where ever it is optimal for the group or the content). The students and teachers can meet, carry out hands-on laboratory exercises, and so on.

This concept for CPD programmes has been in operation at the AAU for several years. This concept of combining PBL, IT-based distance education and face-to-face seminars is now widely accepted and appreciated, so much so that the AAU has been asked to apply it to other programmes with less content.

Work-Based Learning

When carrying out face-to-face courses, competence development is only possible if a course is accessible, either for individual enrolment or as onsite courses. These courses must be taken at a given speed and at a given time without any possible consideration of individual needs. Streamed or videotaped courses offer flexibility, but normally there will be no dialogue between

participants or between participants and a teacher.

The idea of Work-Based Leaning (WBL) as a tool for Continuing Professional Development is to develop a learning process that:

- Is integrated in the job task.
- Does not require absence from work or family.
- Ensures professional relevance.
- Is integrated in the organisation.
- Is adapted to the individual concerning the content, extension and speed.

The experience in PBL gained by the AAU since 1974 has been complemented by the experience from Glasgow Caledonian University (GCU), Glasgow, Scotland, UK, in work-based degree programmes [10]. WBL is recognised as a vocationally-oriented further development. Table 1 lists the differences between learning by problem-solving and engineering problem solving.

Table 1: Differences between learning by problem solving and engineering problem solving.

Learning by Problem Solving	Engineering Problem Solving
- The problem is a tool	- Professional skills are the tools
- Learning is the goal	- The goal is to solve the problem

Following the individual learning goals established by WBL, the learning process is integrated into the daily engineering productive work. The learning speed, as well as the professional content and goals, are defined individually.

A new task for competence providers, such as university professors, will be the transformation of identified competence deficiencies into learning goals. This transformation must be carried out in cooperation between the competence provider, the competence receiver and the company represented by the human resource manager or the team leader.

When some competence deficiencies are identified among individuals or a group of engineering staff, a plan of competence transfer is negotiated between the engineers, their manager and the ELITE. This negotiation ends up with a contract between the three partners that defines the following elements:

- Learning goals.
- Learning/pedagogical means.
- Milestones/tasks for the student/engineer.
- Success criteria.
- Involvement from the company.
- Involvement of the ELITE.

Organisational Learning

Individual-oriented competence development, like courses with individual enrolment, includes the risk of being a waste of money and time for the organisation. The course might not be 100% relevant to the participant and the timing of the relevant issues to his/her needs might not be optimal. Bad timing means that the knowledge input is either too late or too early, ie the engineer is not going to use the new knowledge, which runs the risk of not consolidating the engineer's competence.

The single element of competence development must be pre-defined in the CPD plan for the individual and the team/company in order for them to benefit the most from the investment in the development of new competences. Each learning element must include a definition of the purpose of this activity, identification of the correlation between the content of the learning element and an overall learning strategy and evaluation of the outcome of undertaking the task.

Participants in CPD courses are never faced with the demand of justifying the relevance of the course afterwards – only beforehand. It is perhaps even more pertinent for a group of colleagues to go through the course in a very condensed form and highlight to them the most important issues of the course. In this way, the learning process of the course participant will be improved and, as such, the organisation will also benefit.

The benefit to the organisation is more obvious in WBL. The learning process, goals, content, form and timing is planned to optimise the situation for the participant and for his/her team. The content, form or timing can also be revised based on the context; the transformation of knowledge into the organisation can be an integral part of the strategy.

DISCUSSION

As there has been no tradition for Danish universities to be involved in continuing education of academics, and as the demand for academic training has become more and more prominent, the Ministry of Education of Denmark decided to facilitate the process of university involvement in the continuing professional development of academic skills. In 2001, the Ministry funded six universities with initial funds of approximately US$ 2 million to become involved in CPD. The ELITE Centre was the outcome of this process at Aalborg University.

There is no tuition fee in Denmark for university study as the Ministry pays universities for each student who graduates. Continuing educational programmes, such as two-year part-time degrees, are partially paid from tuition fees and government funding.

The initial funding was meant to facilitate resources for the development of more of these part-time continuing educational programmes. However, as stated above, the ELITE will focus more on the further progression of the concept of continuing engineering education using short (onsite) courses and WBL.

The nature of the organisation's strategies for continuing education will vary considerably depending on the organisational culture, history and management perspectives on a particular problem.

Most companies are aware of the need to allocate additional resources for continuing education and these expenses become a part of the operating budget. However, in many companies, the management trusts the individual engineer's ability to assess his/her own needs pertaining to professional development. Thus, it is actually the engineer who determines whether he/she will participate in a continuing education programme.

Other companies are structured into teams of engineers and the team managers are responsible for assessing the professional skills of the group, as well as the planning of Continuing Professional Development. This means that implementation of CPD will mainly be a function of the team manager's ability to cover all responsibilities; if the team manager is busy getting a team to meet a deadline; then CPD is not likely to be on the team manager's mind and agenda.

The innovative company has an active management practice in which the product strategy is continuously revised. This requires a continuous evaluation and re-evaluation of the engineer's technical professional skills. Whenever a lack of necessary skills is identified, the engineers are either replaced or professional development programmes are implemented.

Very few managers believe that graduate engineers, who have completed a research-based education by definition, do not need continuing education as they should know how to acquire new knowledge. In such companies, time and financial resources will not be allocated for continuing education.

The organisation and strategy of the university are similarly influenced by cultural, historical, political and economic factors, and this is in addition to the prevailing research traditions. There are very proud *academic traditions*, especially at older, more traditional universities, which often means that little or no basic educational and pedagogical changes can occur. Research at these institutions is often *basic* or aimed solely at reaching higher levels of theoretical knowledge in narrow fields.

Other more innovative, technical universities have directed research towards a combination of application-controlled and discipline-oriented research. Universities in which there is a sustained interest in applied theoretical education may be much more open to the demands and changes that occur outside the university environment and may, therefore, be more open to undertaking new tasks.

The intensive technological innovations prevalent today have created a significant need for methods and approaches that can provide ongoing and continuous professional development of industrial engineers. This is despite the numerous obstacles that may arise with the implementation of a continuing education programme.

For a large number of these engineers, especially those responsible for the application of new technology within their organisation, it is becoming increasingly difficult to obtain and maintain the high level of professional knowledge and skills demanded by industry. By taking advantage of the research activities and educational experience existing in the university system, private organisations may well be able to satisfy their needs for the Continuous Professional Development of their engineers. It has become a challenging development for both companies and universities.

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BIOGRAPHY

Assoc. Prof. Flemming K. Fink is currently Director of Studies in Electronics and Information Technology at Aalborg University, Aalborg, Denmark. He received his MScEE from Aalborg University in 1978. Subsequently, he was a researcher at Odense University and established an educational programme in Digital Signal Processing at the Engineering College in Odense. Since 1986, he has been with Aalborg University doing research and teaching within speech recognition and digital signal processing. His major research is in auditory modelling, and he has patented a new concept for parametric hearing aids in cooperation with three colleges.

Fink has been Director of Studies since 1993 and has initiated an internationalisation of the curriculum. He is presently doing research in Continuing Engineering Education as Head of the Centre for Continuing Engineering Education in Electronics and IT (ELITE). Currently, he is also Director of the UICEE Centre for Problem-Based Learning (UCPBL), a satellite centre of the UICEE. Fink has published several papers on Problem-Based Learning (PBL), university-industry cooperation and Continuing Professional Development (CPD).

Fink is member of The National Advisory Board for Technology in Denmark, a Senior Member of the IEEE and represents Aalborg University on several national and international boards.