Continuing Engineering Education as Work Based Learning
- Results from an EU Leonardo Project

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1. Abstract

A European Union funded Leonardo da Vinci Pilot Project on Work Based Learning ended September 2005 (Leonardo 2003). This paper gives some of the key findings from this project. The project idea was to bring together a number of European universities exploring the area of Work Based Learning (WBL) in relation to Continuing Engineering Education (CEE). The paper discusses two areas of the overall project.

- The role of tacit knowledge and its interaction with explicit knowledge in WBL
- Combination of experiences from Problem Based Learning with WBL

The conclusions for the project are based on tests from industrial cases carried out in the United Kingdom, Spain, Portugal and Denmark. Also partners from Finland, Austria and Hungary have been involved in the project. Results to be discussed includes problems with understanding the concept, needs for teacher training, benefits for the learner and her/his company, need for a dynamic learning contract, and the issue of defining learning objectives. Also discussed are the issues of priority given to learning agreements compared to other activities in the company and the importance of a company strategy and culture that includes learning. Two processes are proposed; Facilitated Work Based Learning (FWBL) and Continuous Professional Development (CPD) by WBL Toolkit.

2. Introduction

It is characteristic for high technology companies in Europe that the technology and the market is innovating and changing so fast that the enterprises are exposed to severe pressure, thus requiring innovation and flexibility, which result in changes of processes and structures. The competences of the employees are one of the main competitive parameters in business and therefore it is very important to develop and manage these to match company strategies and market demands. Competence Development by following traditional face-to-face courses is only possible if a course is accessible – for individual enrolment or as a specific company course. The employees often have to follow these courses in a given sequence, at a given time without any possible consideration for individual needs. Competence development like courses with individual enrolment includes the risk of being a waste of money and time for the company.

Integration of facilitated competence development such as Work Based Learning (WBL) as part of a work task in an organization is in great demand. In WBL, the benefit to the enterprise is more obvious. The learning process, the objectives, the content, the form and timing is planned to optimise the situation for the participant and for his/her team. The content, form or timing can be revised based on the context, and transformation of knowledge into the company can be an integral part of the strategy. This opens new opportunities
for the industry to benefit from the latest university research results with major influence on company competitiveness, and in a dynamic world, the importance of employability cannot be exaggerated.

Life Long Learning is a key point in vocational training strategies of the EU commission, and Work Based Learning is a very cost effective way to combine staff development and organizational learning. The consortium behind the project ‘CEE as WBL’ (Leonardo - project, 2003) consisted of 15 partners in 7 countries all of whom are concerned with how they the best possible way can meet the continuing needs for engineering knowledge. The staffs participating were a mixture of engineers and educationalists and partners involved 8 universities, large and small engineering companies, and The Danish Society of Engineers (IDA).

**Tacit and Explicit Knowledge**

One development within the project has been to investigate the role of tacit knowledge, and its interaction with explicit knowledge to achieve enhanced delivery of CEE. This work package is led by the partners from Caledonian University, Glasgow and University of Wales Institute Cardiff, United Kingdom.

Tacit knowledge is now well recognized as being the greater level of knowledge in most organizations. It is interpreted as knowledge which is hidden within the human capital in the form of intuition, beliefs and values which are developed through experience and which lead to individuals with a mindset which is made up of a unique set of beliefs which control what they see and do and which affects the way they interpret explicit knowledge. Alternatively explicit knowledge involves what has been written and what is spoken. Thus individuals progress from data gathering through to wisdom and as such their depth of meaning grows resulting in an interpretation shift from being essentially explicit at the data/information stage to fully tacit at the point of wisdom.

The research has involved studying how the CPD process can be developed through understanding the interrelationships of tacit knowledge, explicit knowledge and advanced knowledge based skills. The research and experimental testing was developed to provide an in depth understanding of the level to which organizations were aware of the value of tacit knowledge in their organization and to assess the factors which would inhibit tacit knowledge flow and transfer. The approach involved using PBL situations, change situations and project based situations in the work based environment.

### Combining PBL and WBL

A wealth of experience from on-campus facilitation of learning in team organized problem based projects has given the idea of transforming this experience into an industrial context (Fink 2003). A life long learning methodology for research based facilitation of learning processes and development of engineering competence as an integrated part of the daily work is developed. This new methodology is developed by Aalborg University, Denmark and cases are performed in Denmark and by Mondragon University in Spain.

### 3. PBL and WBL Background

Continuing Professional Development (CPD) for engineers includes the development of professional theoretical skills in addition to the practical work functions i.e. a combination of continuing engineering education along with productive engineering. Most innovative companies are aware of the
importance of improvement of professional competences, but even though professional development is identified as vital for the future of the company, the individual engineering staffs usually indicates that they must use their own time for CPD courses. As such they are not integrated in the time-plan for the project. Money for financing the course is normally no problem – but time is. Another parameter which needs to be considered is the recognition of the course as being part of the personal curriculum – which means that some kind of accreditation may be desirable. This means that CPD-programmes must be developed to meet the expectations of both the managers as well as the engineers; programmes that integrates new academic knowledge into the productive daily process of the engineer.

Problem Based Learning
Implementation of Problem Based Learning in full time educational programmes has shown that learning by applying the theoretical material in engineering problem solving is a strong way of learning (Kjersdam and Enemark, 1994), (Fink, 2001).

One cornerstone of the PBL concept from Aalborg University (AAU) is the team organised project work. Each semester at least 50 % of the students’ time will be dedicated to one big team organised project – approximately 3000 men hours for a team of six students. The projects will often be on solving real-life engineering problems, and the university professors therefore have great experience in facilitating the students in their learning process as part of the project work. The objective is to learn – not primarily to solve the problem, but of course the students will normally do that.

We see many similarities between the students’ project work and modern team-organised engineering in industry. In carrying out the engineering task the engineer might seek information in a textbook, in scientific papers etc. and thus apply the information from here to his development task. Additional knowledge transfer from university is however needed and must be added. The main purpose here is not to learn, but to solve the problem, and the increase in competence level is a necessary and desired side effect.

Work Based Learning
Work-based learning is the term being used to describe a class of university programmes that bring together universities and work organisations to create new learning opportunities in workplaces (Boud and Solomon 2001).

Work Based Learning was first developed at Glasgow Caledonian University (GCU) in 1991 leading to a range of programmes and research activities. At GCU, work based learning methodology was adapted to address engineering education at pre-university level, undergraduate level, postgraduate level and at continuing professional development stages of education (Burns and Chisholm 1998).

The first model is one based on a programme of study that is totally associated with activities in the workplace (Burns and Holifield 2001). Programmes using this model are normally based on a three-way partnership, which involves the company, academic institution and student. The resulting programme is referred to as a learning agreement, learning contract or a learning programme (Burns and Chisholm 1998) (Burns, Westwood and Chisholm 1998).

The second model shows that it is not necessary to have a programme wholly defined by workplace activity. Programmes may be a mixture of taught modules and work-based activity. Programmes with this mixture of activities have been used to define
programmes that are postgraduate or under-graduate level.

The third model enables the recognition of skills and knowledge gained as a result of workplace activity. Programmes for this purpose normally involve an element of assessed prior experiential learning and involve elements of both explicit and tacit knowledge and some study of defined modules.

The fourth model, the thematic approach refers to programme structures that enable WBL to be adapted for groups of students at Masters level programme and has a core studied by all participants followed by differentiated work-based projects. An alternative to this is where all participants study the programme, in its entirety, each completing the same modules and work-based assignments. These programmes are often referred to as thematic programmes (Weaver, Chisholm and Burns 1999).

Combining PBL and WBL

On of the ideas behind this project was to combine experiences from Problem Based Learning with experiences from Work Based Learning into a new methodology called Facilitated Work Based Learning (FWBL). Another of the main ideas behind the project was to provide CPD by WBL where the entirely new concept was introduced of integrating tacit knowledge with specific and relevant explicit knowledge to underpin the delivery of learning in the workplace alongside the delivery of organisational competence development for the participants. Both these ideas are described in more detail in later sections of the paper.

4. The cases

Cases were carried through in Denmark, Spain, and United Kingdom. The cases are all inspired by the idea of WBL as mentioned above. Each university has contributed with their experiences within continuing engineering education and therefore the cases are all different in regards to research area and methodology.

In Denmark cases were carried out in two different companies. The cases are very different in professional depth and extent, duration, numbers of learners etc. But both cases are grounded within SW-engineering. The focus of the cases in Denmark is to test Facilitated Work Based Learning. The case in Spain involves learners from two different companies and from different departments within these companies. The learners however have common learning objectives within project management. Also these cases are testing FWBL. In United Kingdom the focus has been on developing a CPD by WBL Toolkit on CEE for companies to be used in their work with Tacit and Explicit knowledge. The Tool Kit were tested in two companies in Wales, and in Portugal the use of web based learning as support for WBL was tested.

5. Facilitated Work Based Learning

In the previous section the idea of Facilitated Work Based Learning (FWBL) was briefly introduced. In this section the FWBL is discussed in depth and is compared with PBL and WBL to facilitate an understanding of the similarities and differences of the methodologies.

PBL - Problem Based Learning is on-campus studies. The learning objectives are academically defined in the curriculum which is prepared by the university and in some countries approved by the government or an accreditation body. A major part of the curriculum is dedicated to projects in teams, and the learning outcomes will be assessed thoroughly. The aim is for
the student to obtain a degree. (Kolmos, Fink, Krogh 2004)

WBL – Work Based Learning can be either an individual learning programme or a thematic programme for a group of engineers where competences / knowledge based skills are developed and evidenced through delivery of the work set by the organisation (Chisholm 2003). The learning objectives are the subject of negotiation between the University, the company and the learner. Work Based Learning also relates to Workplace Learning which involves the completion of learning objectives within the curriculum of a degree through the use of the workplace environment and the work programme of individual (Chisholm 2003). Here the negotiation involves agreement with the organisation and the learner that the work programme is suitable for delivery of the learning objectives set within the academic degree programme.

FWBL - Facilitated Work Based Learning is a learning programme designed for individuals or groups of engineers in a company. The learning takes place in the company and the learning objectives are defined to match the competences strategy of the company. The aim for the learner is to be better qualified for her/his job. FWBL can be described in different continuing phases. However the content of each phase is not unambiguous for all FWBL programmes as the distinctive mark of FWBL are precisely their individualities. The FWBL programmes are designed not only to meet competence needs of the company but also to match the preferences of the individually engineers - the learners. FWBL can be characterised as a partnership between three partners - the company, the learners and the university as facilitators. This partnership is very important for the success of the FWBL programme. All partners are equally responsible for the programme which means that commitment from all is essential.

The process of FWBL does not follow a rigid scheme such as a standard five day course. This learning process will normally run for more than half a year and often much longer depending on the extent and depth of the learning objectives and the time frame of the project in which the FWBL is incorporated. A prerequisite to FWBL is the knowledge and experiences of PBL as the pedagogical method. Furthermore it is very important that the companies involved in FWBL are organized in teams or project groups. The FWBL process can be described in 5 continuously phases:

- Contact phase
- Defining Learning objectives
- Defining Learning contract
- Implementation of FWBL
- Evaluation

**Contact Phase**

The contact between company and university is often new for both parts, or at least the situation might involve new persons. To ensure a fruitful collaboration it is very important to ensure everyone involved is in agreement. Therefore the time used on harmonizing wishes, expectations and request is often very well refunded. The company (strategic leaders) will introduce the overall theme of the learning objectives - professional area, extent and depth, and relate it to the company internal project in which the FWBL programme is needed. But very important is also that the strategic leaders are familiar with the FWBL method and the difference between this method and more traditional methods of CEE. The university will in this phase focus on communicating the FWBL
Defining Learning objectives
The process of defining the learning objectives is essential to the success of the FWBL programme. The contact phase is the introduction phase - now it is important to be exact. The university researcher will in a dialog with the strategic leaders of the company establish a very precise description of their preferences and requirements for the learning objectives. This precise description will partly be based on what is needed in their engineering project and partly on the engineers (learners) involved in the FWBL programme. Based on the definition by the strategic leaders the university researcher will carry out interviews with each individual learner to expose the professional competences of the learners and try to match it to the learning objectives defined by the leaders.

The dialogue in this phase will definitely have a power asymmetry. The university researcher defines the situation, introduces the theoretical subject to be discussed and guides the learning objective definition process by asking predefined questions (Kvale 2005). However, the university researcher must be aware that the aim is not to meet objectives for academic reasons but for the learner to obtain competences and skills needed to solve engineering problems.

Defining Learning Contract
The learning contract is prepared according to the outcome of the previous phase. The overall theme is defined by the strategic leaders and the individual competence level of the learners. The learning contract is negotiated and signed by all three partners to create a feeling of ownership and to commit all on an equal basis. The learning contract will as a minimum consist of:
- Definition of an overall theme for the learning programme.
- Identification of learning objectives
- Agreement on Learning methods
- Agreement on Learning time frame
- Definition of success criteria for the learning process
- Description of process and outcome assessment

Implementation of FWBL
When the learning contract is signed the FWBL programme is ready to start. This of course is the most important phase in FWBL - now the learning will actually take place. The contents, proportions, professional area and time frame of the FWBL programme will depend on what the three partners agreed within the contract. In an attempt to integrate the learning in the organization, the training will take place in the company. The facilitator (researcher) from the university will give face to face training to the learners and will continuously make sure the learning is in progress and in accordance with the learning contract. It is very important that the facilitator is not presumed to be a consultant with the purpose of helping the learners to solve their problem. The facilitator will always focus on theories and methodologies to help the learners solve their problem and find solutions.

Evaluation
Evaluation will have two targets. Firstly to ensure quality of the FWBL programme and secondly to make sure that the learning objectives are accomplished. The FWBL programme will be subject to an evaluation through the whole programme. The purpose of this evaluation is primarily to ensure the quality of the programme and if
possible and necessary to modify the programme and the contract. The evaluation of the learning objectives will be according to the description of the evaluation in the contract.

6. CPD by WBL - Toolkit

The main result of the research on the interrelationships of tacit knowledge, explicit knowledge and advanced knowledge skills was the development of a WBL-CPD toolkit. Each tool contributed to integrating tacit and explicit knowledge to deliver and enhance organisational competences. Various approaches to developing the model were considered and after a study on toolkit development from the literature including that by Hubert Saint-Onge (2001), it was decided that a toolkit approach was ideal. Early in the experimental feedback it became obvious that this integrated and systematic approach was required if effective integration of tacit knowledge, explicit knowledge and knowledge based skills was to be achieved.

The basis of the research was the known fact that for any organisation intellectual capital consists of human capital, customer capital and structural capital, where within each subset there are two forms of knowledge; explicit and tacit. It has been shown (Hubert Saint-Onge 1996) that tacit knowledge represents the more significant and greater knowledge in organisations.

The tools comprising the toolkit underpins the cycle of tacit knowledge and its systematic reshape through individuals participating in learning sets/groups where each individual through reflective practice is able to surface deep held values and assumptions about how to solve problems, take forward change and conduct projects. In this way the tacit aspects are made explicit. Thus through the tacit ⇔ explicit interaction, the individual achieves the enhanced continuous engineering education organisational competences. The Toolkit is designed on the basis that a partnership is developed between a participating organisation and a Higher Educational Institution, where trained academic staff facilitate the CPD by WBL. The Toolkit consists of more tools:

- The Learning / Development Agreement Tool is used to define the CPD by WBL in the form of a learning development agreement as the vehicle through which to achieve the CPD outcomes.
- The Learning Needs Analysis Tool is designed to analyse the learning needs of the organisation in relation to the operational CPD by WBL for the engineering personnel.
- The Development of Reflective Practice Tool is designed to develop competence in reflective practices such that the work-based learning can be used as the basis to achieve novel CPD involving the interaction of tacit knowledge, explicit knowledge and knowledge based skills. This tool is the starting point for the CPD by WBL.
- The Learning Set and Working Styles Tool is the key to establishing learning through a team working approach. This tool is designed to obviate a major obstacle to effective learning; that of disruptive working/learning style which could destroy tacit knowledge understanding. Effective WBL and tacit knowledge flow and transfer can only be achieved where mutual trust and respect are established and these can only be established if participants understand others and their own working styles. The tool facilitates modification of working style.
- The Barriers to Learning Development Tool facilitates the
Learning Set identifying barriers to progress of the work based project, particularly evaluating tacit knowledge.

7. Findings and Discussion

Understanding the Concept
We have experienced that it’s crucial to make sure that all partners in the WBL or FWBL programme understands the concept and their individual role. First of all we must be aware that academic staff and engineers from industry are using different languages. In industry needs are defined as tools and solutions, but academics are discussing in terms of methods and theories. In a given situation we must make these two languages converge into a common understanding to succeed with the definition of learning objectives.

It is very important to stress that the focus is on learning, not on teaching. In many cases it is expected that the emphasis will be on the development of skills and competences rather than academic objectives. For university staff not familiar with WBL or with PBL it will often be difficult for them to understand how they can facilitate a learning process without academic courses. For university staff familiar with WBL it is difficult to understand the FWBL concept without aiming at a degree or formal academic assessment at the end. Based on these observations we have come to the conclusion, that some fundamental teacher training will be mandatory for academic staff involved.

Defining Learning Objectives
Defining learning objectives is perhaps the most difficult part in setting up the learning contract. Most companies do not have a vision for the development of their competences or skills, nor do they have a strategy for their knowledge development. They simply identify – instantaneous - when they need some specific knowledge or tools. As mentioned above, engineers in industry and university researchers are using different professional languages. It is very difficult for an engineer to define by worth something he does not know. Therefore it is very important to have well trained university staff that can analyse the company situation or development task to assist in the identification of the learning objectives. Also we have identified that the objectives that can be defined in dialogue with the engineer might not be the same as we will find in dialogue with his manager.

Benefits for the Learner and Company
Being able to improve your skills and being able to increase the organisational competences without sending staff away for on-campus courses is very attractive for many engineers and managers. Some of the benefits from the FWBL concept and CPD by WBL toolkit are identified as:
The programme will follow learning objectives defined from the needs of the engineer and the company. The learning objectives and/or the learning methods can be adjusted dynamically. The learning speed will be adjusted to the needs and time resources. The learning will be integrated into the organisation along the process. For example, in one of the cases the learning staff involved in the process was substituted in the middle of the programme with only minor delay.

Importance of Learning Contract
The Learning Contract is not just written as part of the initiation of the full programme. The Learning Contract is an important document defining issues like - what are we supposed to do (learner and facilitator), how much time is available for the learning process, etc. In a dynamic modern industry the situation however changes quickly, and the contract will therefore need continuous updating. But, as the learning process still normally will be a minor part of the full working hours (like 8 - 10 hours per month) it is important to have a written agreement on what is supposed to happen. New tools should therefore be developed to make the Learning Contract more dynamic. The Learning Contract must be an active part of the process, including learning milestones. The contract can also form the basis in an eventual accreditation process.

Importance of Company Strategy and Priority given to Learning Activity
An important observation is that a firm control of the process is needed and this must be done by the university. As a major part of the interaction between the university and the company will be informal discussions or ad hoc courses and this is often seen by the company as an activity which can easily be postponed. This however can cause problems with the planning of new activities, and the full programme might suffer from that. We therefore have to find ways of defining strong commitment from the industrial organisation. The CPD toolkit addresses this problem through a formal learning needs analysis.

8. Conclusion

The need for continuing engineering education is still increasing – but time made available by organisations is still limited. Integration of CEE into the everyday engineering task might be an answer to that problem. The idea of WBL, FWBL and CPD by WBL toolkit is very positively accepted by industry. To be involved as university teacher in such a process, the teacher must develop some additional skills in addition to the academic knowledge. Teacher training courses must be developed and be mandatory for the university teachers – the facilitators for WBL and FWBL. For a small or medium sized enterprise (SME) it is not possible to pay for a traditional course-on-demand. The CEE process described in this paper is well suited for individuals or small teams of engineers and hence also for SME’s. Besides the development of teacher training programmes we must improve the dynamic use of the learning contract. A tool for management of a FWBL is needed. As the process normally will not follow an academic defined curriculum but enterprise defined learning objectives, it can be a big task to keep the company committed continuously to the programme if other production tasks are requiring their attention.

The CPD by WBL toolkit provides a new operational paradigm with the
introduction to FWBL in organisations where tacit knowledge is integrated with explicit knowledge to solve problems in the workplace and as a result participants achieve organisational competences and knowledge based skills. The experiences described here are from a project supported with EU funding. In the future we will be running FWBL and CPD as WBL toolkit as full commercial activities, which as such will give the enterprises more commitment to the contract signed.

9. References


