New Teaching Strategies and the Interaction between Continuing Engineering Education and Regular Engineering Study Programmes

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Abstract: Innovation and quality of education play an increasing role in (under)graduate study programmes and in continuing education for engineers. Technology enhanced learning and teaching can foster the development of educational quality – if implemented and applied in an appropriate way. When applying technology enhanced learning many teachers recognise that it is not sufficient to seek technical solutions for didactical problems but that they also need didactic solutions for technical problems. This first step towards increasing the interest in educational theory among teachers in technical disciplines is not sufficient to push the development of educational quality. Supporting activities and accompanying measures are necessary. Elaborated support structures and a sustainable quality management covering all processes and products of the university are necessary preconditions for achieving the intended results. The interplay of regular study programmes and continuing education can contribute the missing impulse to initiate a sustainable process of quality development.

Status Quo: Different Orientation and Speed in Economy and Education

In the present economic situation, companies have to face new requirements week for week. Technologies change rapidly, new work processes and methods are developed, product and market systems are becoming more complex, and outsourcing to cheaper locations is a daily reality. Innovation and product development are key success factors to prevail in the market. For engineers working in industry, the challenge is not any more to find a technological solution to a given problem, but to master instrumental and competing relationships, to assess values and norms, to set goals and standards, and to take decisions that can be carried out by all parts of society. Leadership qualities and the ability to work in inter-disciplinary teams are the competencies companies are looking for.

Many universities still perseverate in their successful tradition and teach engineering programmes nearly in the same way as they did for decades. Practice follows lecture – discipline for discipline and teacher for teacher. Engineering curricula and individual courses are mainly or exclusively focused on transmitting knowledge: Teaching of theory and practicing for technical skills. Creativity, social and economic responsibility, political thinking and social skills stay out of the scope of most engineering study programmes.

Universities and other organisations offering professional development and continuing education will have to understand and to recognise that academic traditions do not suit the needs of economy any more. What companies need are employees (university graduates) who are able to solve unstructured problems, work in a self dependent way, act with at least a minimum of economic and social responsibility, and show motivation and capability for self-directed continuing education (Horvat 1988, Reichl 1997). Consequently, the demand for inter-disciplinary and

personalised offers in Continuing Engineering Education (CEE) which are able to meet these needs is increasing. Personalised learning itineraries are necessary to fit companies´ needs. Requirements like the lack of time for education and therefore the need for a flexible and modular structure for a student-centred and self-regulated way of learning reflect an extremely important aspect of the requirements of industry (Jerlich, Reichl, Obermüller 2006; Reichl, Jerlich, Obermüller, Herbst 2006).

This was impressively confirmed by the findings presented at the World Conference on Continuing Engineering Education (WCCEE), saying that the following requirements are crucial for the success of CEE (Reichl, Jerlich, Obermüller 2005; Jones, Krieger, Reichl, Steiner 2006): Courses have to be inter-disciplinary and cross departmental, offered internationally, delivered on the basis of concepts open to personalisation, and adapted to target groups. The challenges faced by companies generate demands for new ways of learning as mirrored in terms like just-in-time learning, learning on demand, or development of new competencies.

Conflicts resulting from different speed of development in economy and education – which partly are not yet visible – can only be solved by using active, continuous and perceptive communication between all parties involved. This does not only include students and teachers, tutors and coaches, but also the directors of Human Resources and Research & Development departments of industry as well as leaders of academic institutes and university departments.

Industry requires that learning and working are not divided anymore. This results in the demand for education using real life or close to real life projects. The principle of learning-by-doing, based on the concept that successful learning only takes place when acquired knowledge can also be applied and experienced, has to be taken into account, integrated into educational course design (Reichl, Payr, Csanyi, Vierlinger 2001).

In theory, we know what has to be done. However, in practice it seems to be nearly impossible to do it, due to strong traditions and rigid attitudes towards academic teaching widely spread among university teachers. Thus, a solution to bridge this gap is needed.

Bridging the Gap with Technology Enhanced Learning

Technology enhanced learning holds different potentials that could make it the starting point – although not the final solution – of quality development in academic and continuing education.

The arguments for technology enhanced learning on the organisational level are not at all new. Participants are independent of time and space. Learning resources (content) and communication between students and teachers are available and accessible always and everywhere. Courses may comprise job-related experiences and problem situations as well as the knowledge of international experts and local practitioners. Another main advantage on the organisational level is the chance to increase the efficiency of teaching utilising some functionalities of modern learning management systems, e.g. communication and feedback tools, student administration tools, or testing and assessment tools, so that large course groups can be handled with comparatively little effort.

These advantages have – empirically spoken – already convinced a number of individual university teachers, departments, and even complete universities to deliver their study programmes and/or continuing education offers in the way of technology enhanced learning. According to our experiences in the past decade, it seems realistic that many will follow within the coming five to ten years. However, described in terms of didactical efficacy and of better learning outcomes, applying technology enhanced learning and teaching would not automatically improve the quality of learning. The advantages offered by technology enhanced learning can be exploited fully only in combination with appropriate educational theories and strategies. One of the problems is that students are expected to act in a rather self dependent way, but in the past some of them never had the chance to acquire the competencies necessary to do so. This threat is at the same time an opportunity: technology enhanced learning opens the chance to continuously develop autonomy, responsibility and also working discipline.

Another typical problem is the lack of motivation and activity of students – critical elements for the success of learning processes in general and particularly for technology enhanced learning. Again this threat is likewise an opportunity: If teachers stop “spoon feeding”, addressing the “average learner”, and start asking questions, posing

assignments and giving detailed feedback they will to a much higher extent meet the needs and the motivational background of their individual students. In a nutshell: technology enhanced learning will work much better – in terms of efficiency and efficacy – if the learners are given the opportunity to take on responsibility for their learning process and its outcome. This well known concept is often and consequently ignored in academic teaching – for reasons of idealistic tradition and individual lack of insight.

Nevertheless, insight alone is not enough. The understanding that technology enhanced learning can only be successful if there are self-responsible students leads to a painful lack of concepts and competencies to put it into practice. Self-directed learning follows different patterns and needs other measures and resources than traditional teacher centred education. Technology enhanced learning offers better opportunities to deliver a self-constructed and self-regulated way of learning than traditional teaching.

But to achieve these goals, the teachers' role has to change drastically. They have to back out from teaching and take the role of a facilitator or coach. The most important factor of technology enhanced learning hereby is to address and/or stimulate the motivation of students under the conditions of self-directedness (Reichl, Vierlinger, Obermüller 2004). This role is very different to the "spoon feeding" type of teaching and needs very different attitudes and competencies on the side of teachers.

Speedup and Backup for Necessary Changes

Having observed the development in the education market for approximately one decade, our experience is that a considerable number of teachers have become aware of the necessity of adequate teaching strategies after having gained intensive experiences with technology enhanced learning. On the other hand, it also became clear that the individual development from the awareness of the problem (technology is only a powerful tool, not the solution of didactical problems) to the knowledge required for implementing solutions (didactic concepts and competencies for applying this tool successfully) takes a lot of time.

Within the last ten years, a minority of university teachers have actively gained experiences with technology enhanced learning – and only a fraction of these experienced teachers came to the conclusion mentioned above. Consequently, innovation as described above is still in the hands of a few pioneers, and results of their efforts are not yet sustainable. Therefore, persons responsible for professional development as well as for continuing education on individual, institutional and national level find themselves challenged to decide to either leave everything as it was before (and probably perish in the increasingly competitive educational market), or to enhance individual processes of awareness and development of necessary competencies with all available accompanying measures.

Following other European countries, the Austrian Federal Ministry for Education, Science and Culture (bm:bwk) and most of the Austrian universities have made this decision and started strategic development projects like Delta 3 (Fröhlich, Herbst, Reichl 2005; Delta3 2006; Henkel, Herbst, Krameritsch 2006). The goal of these projects is to find out how individual processes of awareness and development of necessary competencies for boosting teaching quality with technology enhanced learning can be tied together and assisted by institutional strategies in the best way.

According to the current state of our findings, we suggest three bundles of accompanying measures: support structures, quality management, and change management. Support structures are important to perpetuate individual motivation for change, to boost the educational quality of experimental courses, to provide experiences of success for pioneering teachers, and to increase the job satisfaction of such teachers. Thus, support can become the *pull* mechanism of change. Quality management – with all its possible consequences – provides a substantial backup for the idealistic motivation of pioneers. Thus, it can become the *push* mechanism of change. Change management, after all, allows an institution in development to put an end to old and ineffective structures and to build new and effective ones without destroying the whole institutions themselves.

Concerning their (learning) motivation, teachers react similar to other practitioners and adult course participants (Reichl, Payr, Csanyi, Vierlinger 2001). They are prepared to perceive new information in that moment when *they* need it – and not when some experts think they should have it. Following this concept, support structures with the goals described above will have to be extremely flexible and personalised.

If a question appears (in the context of deciding about or applying technology enhanced learning or new educational methods and strategies like self-directed learning) there must be the right answer in an adapted balance of abstract vs. concrete, cursory vs. detailed, short vs. extensive, on an expert level vs. a novice's level, and – most important – as soon as possible. This ideal is – as so often in real practice – foiled by institutional and financial restrictions. At Vienna University of Technology, we therefore experiment with compromises. We offer a combination of web-based problem-oriented information with phone-based helpdesk, individual counselling / coaching, and a workshop programme supplemented by information events and meetings of practitioners.

Thus, if a teacher (or a tutor or a managing person) at our university has a question, she or he can choose one or several of the following options to find an appropriate answer or solution:

- find and read the corresponding FAQ ("frequently asked question", answer not longer than ten lines),
- find and read the corresponding short paper (not longer than one page),
- find and read the corresponding article (maximum ten pages) with links to further articles on the internet,
- call the helpdesk,
- make an appointment for counselling or coaching (individually or as a group),
- book a workshop (duration from three hours to one day),
- register for an information event,
- participate in the next get-together (e-learning jour-fixe, e-learning update).

This support programme is work in progress, but we can already see by the numbers of contacts with our customers that individual just-in-time services (counselling) seem to be much more attractive than time consuming social situations (especially workshops). This experience fits the theoretical assumption above.

On the support level, we (at the E-Learning Centre of Vienna University of Technology) try to answer every question as well, as soon and as individually as possible. We aim to give our teachers the feeling not to be alone. We "nurture" them to allow the "feelings of success".

Quality Management and Change Management

One of the strongest motivations for teachers to improve their work is gratification for good quality. So, if teaching quality shall be improved in a sustainable way, a system of quality management on all levels of teaching will be very helpful – from individual courses to complete undergraduate programmes or CEE programmes, institutes, faculties, and last but not least the university itself.

There are at least three ways to award persons and institutions for good quality: finances, time, and prestige. If all three are used to foster quality development in teaching (including technology enhanced learning) the impact will be higher than by addressing only one motivational factor – like for instance prestige. Thus, in addition to *nurturing* by support, a strong complementary impact can be established: *challenge*.

The implementation of technology enhanced, new teaching strategies and quality management (maybe going as far as to new financing policies) will arouse changes in the organisational and social structures of involved institutions. Therefore, a lot of irritation and uncertainty will be caused among the persons involved. Leaving them alone could lead to extensive chaos instead of improved quality and increased efficiency.

To minimise these risks, universities thus will have to take measures to develop professional concepts and set appropriate steps to deal with the challenges described above in terms of change management and/or organisational development.

Interaction between CEE and Regular Study Programmes

Technological and managerial requirements in industry today look similar to how tasks and processes can be set up as a virtual environment on an e-learning platform. Applying technology enhanced learning, real life situations can

be simulated, and practical learning can be stimulated, thus making it an ideal form to foster innovation. Students can act in a virtual environment almost like in real life – and sometimes this *is* real life, e.g. in a scenario of a collaborative team of young engineers in a product development department who geographically are located all over Europe and who are coached and managed by a senior engineer who – depending on the respective problem or task to be fulfilled at the moment – switches between the roles of expert, or coach, and team member. In such a case of work based learning, learning and working becomes the same – thus, it accurately depicts the working environments in industry (Jerlich, Reichl, Obermüller 2006; Reichl, Jerlich, Obermüller, Herbst 2006).

Thus, work based learning is a very appropriate teaching strategy for continuing education, nevertheless also relevant for undergraduate and graduate programmes. Active learning (Reichl, Vierlinger, Obermüller 2004) – in its different forms and fostered by technology enhanced learning – is a significant step towards it. The challenges and also the suggested measures to master them refer to basic studies as well as to continuing education. According to different basic conditions and goals, both areas could therefore co-operate in developing new teaching strategies – generating additional synergetic effects.

Continuing education (CE) is the junior and more flexible partner of the planned development partnership. The personnel involved in a programme are comparatively manageable. The scales of both, content and training time are smaller. Therefore, on one hand, CE is rather open for innovations and experiments than regular programmes. On the other hand, CE is object of quality control by *paying* customers and cannot accept too many experiments for innovation which are unsuccessful.

Regular study programmes (both bachelor and master) represent the bigger and – considered as a whole – less flexible system with regard to educational innovations. Thus, educational experiments might be more difficult (because of strong traditions, little resources and big numbers of students and teachers) but less risky in terms of financial consequences. Students will not stay away from a programme if an experiment with a course turns out to be unsuccessful.

In most cases, teachers running courses in CEE are the same who teach regular students at all levels of professional development. Both educational subsystems of universities overlap in the involved teaching staff. This could be the pivot point for mutual stimulation and reinforcement, e.g.: With a considerable time investment, a professor may start a limited and well prepared didactical experiment (with work based assignments for small teams with online delivery of the results) in her CEE course with e.g. 15 participants. All – highly elaborated – course materials become available for participants on the Learning Management System. If such an experiment is to some degree successful (participants are motivated to fulfil the assignments and deliver rather good results), it can then be repeated in her course in the master programme with e.g. 200 students – with the same content and an adopted concept.

Even if the success of an experiment is not overwhelming (e.g. most students stay inactive and do not seem to be motivated), evaluation results (in the context of quality management) may give enough hints to elaborate an improved concept (e.g.: if assignments were too difficult for one third of the group and too easy for another third, assignments can be provided on different levels of difficulty; if students complained the lack of tutorial support, additional tutorial staff can be granted).

Didactic innovation could thus step forward from experience to experience – every time changing from CEE to basic studies and vice versa. What was developed in a CEE context can be applied in the context of master programmes and reach more sustainability and model effect. Without the initial time investment in a CEE context, the quality development in the master course context might not have been achieved. Without the experiences of the master course, the concept could not have been fine tuned for a CEE target group within a rather short time. Such a co-operation between CEE and study programmes thus facilitates synergies.

Conclusion

Given that universities and educational organisations have to face challenges such as budget cutbacks, insufficient funding or other restrictions that make it difficult to survive, synergies of strategic co-operation are crucial for educational innovation and quality development.

Technology enhanced learning and teaching can foster the development of educational quality; to make the work of "pioneers" in this field sustainable, it is necessary to establish elaborated support structures that cover all educational processes and products of the university.

The Continuing Engineering Education market today is much bigger than twenty years ago. Universities have not yet sufficiently recognised their advantages towards private organisations capturing this market and earning money to re-invest in quality development by applying up-to-date teaching strategies. The re-use of learning resources and of elaborated teaching methods aiming at active learning in different contexts and subjects makes interdisciplinary teaching possible and fulfils industry's requirements. Moreover, a joint development of course material (and concepts) offers innovative ways of re-use in customer training or customer retention programmes.

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