Experiential learning as a method to enhance experiential teaching

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INTRODUCTION

Crucial for the success of Engineering Education (EE) to educate engineers equipped with the knowledge, skills and attitudes they need to meet the challenges they will face as professionals is that faculty has the right competences to, and understanding about, how to enhance learning. One of the roads forward is to use student centred and activating teaching methods. Even if the development of EE in this direction has been going on for several years, still it is hard to make a sustain shift from a teaching culture towards a learning culture at many universities. A teacher-training programme for experienced teachers has recently been developed at the Technical University of Denmark (DTU) where the aim is through experiential learning to learn the participants about and how to use experiential learning in engineering courses. The overall strategy of the teacher-training programme follows the steps in the Kolb learning circle [1] in its pure form, staring with the participants' analysis of their own teaching and of their students' experiences of the teaching they provided. This is followed by theoretical input about teaching and learning in Higher Education (HE) in the stage of abstract conceptualisation. On the background of those stages the participants construct a revised course design and suggest an implementation plan of the revisions. In this paper we describe this new teacher-training programme and the experiences and outcome of the first try out. Finally, we reflect upon whether a teacher-training programme of this kind fulfils its overall purpose to impact development of teaching practice and to what extent the participants make the shift towards to a higher extent use active learning.

1   BACKGROUND

It's common knowledge that active learning methods used in Higher Education (HE) and in Engineering Education (EE) support the students in their learning process in an effective way and helps the students adopt a deep approach to learning [2]. Research about teaching and learning in HE gives support for this and many different paradigms and traditions within this field of research come to the same conclusions [3][4][5][6]. The scientific background for this research stems from the cognitive theory of constructivism [7]. After many years of research about constructivism and try-outs in teaching practice how this theoretical framework could be used to support student learning various teaching methods have been developed building on the cognitive findings and principles behind constructivism. Some of those methods are Problem Based Learning (PBL), Project Based Learning, Case Based Learning and Inquiry Based Learning [4]. One of the central models in this development is the Kolb learning circle [1], which is structured on the background of the research from many well-known theorists in cognitive science. Work from, amongst others, Piaget, Dewey and Lewin lies behind the model of Kolb's learning circle and it also form the teaching and learning foundation for the

active learning teaching methods and are referred to as experiential learning [8]. Going through the stages in the circle important activities, central for human learning is ensured in teaching and thereby the learning outcome among the students is enhanced. The stages in the Kolb learning circle are i) Concrete experience of a case or a problem that should be understood or solved, ii) Reflective observation where the case or problem is analysed with the departure in present knowledge and understandings, iii) Abstract conceptualisation where new theoretical content linked to the case or problem are presented and acquired, iv) Active experimentation where this new knowledge is tried out in the context of the original case or problem, reflected upon and thereby understood in this framework. The iterations in this circular learning process can go on many times. There is a whole theoretical framework developed that has deepened the ideas and the use of this model for experiential learning. For example it's investigated that different field of subjects due to the character of the subject preferable work in some of the stages [8]. This is important information to teachers. In order to ensure learning teaching must be planned in a way that the students is forced to elaborate with knowledge in all the stages no matter where in the learning circle you start the work of the students.

The reason why this model for teaching and learning is so effective in creating learning is because one of the most important findings in cognitive science is imbedded in the model. As earlier stated many contributions of researchers and theorists merged into this model and among them is the early findings of Jean Piaget which divided the learning process into two different phases, the one of assimilation which describe the brains ability to absorb new information and the one of accommodation which describes the process when this new information becomes transferred into sustain mental structures in our brain. Accommodation is the phase where the real learning takes place. To other important mental activities that are involved when new ideas are created divergent and convergent thinking are also imbedded in Kolb's learning circle [1].

Translated into the model of Kolb's learning circle the phase between the concrete experience and the reflective observation is when we focus on the very problem and open up for our brains knowledge resources to understand what we phases are recognised as a process where we use divergent thinking and create different theories about what we experience. The phase between reflective observation and abstract conceptualisation correspond to the assimilative process of learning when we get new information in a systematic way about the situation we study. In the phase between abstract conceptualisation and active experimentation is recognised as a process of convergent thinking where we need to decide which theories we would like to apply to the problem we are dealing with. The last phase in this learning circle that is the one between active experimentation and the renewed concrete experience in a new light correspond to the accommodative process which means that the mental structures has transformed and included the new knowledge in a way that it has formed new structures that helps the brain to transfer the knowledge into new contexts and to make the recalling of the new knowledge easier. Deep approach to learning has occurred [2].

1.1 Teaching and learning in Engineering Education

Students in Engineering Education are educated into a profession where they use theoretical knowledge on a high level in qualified solving of engineering problems. This is a multiple and complex process that requires higher order mental skills where different subjects must be combined in new ways [9]. The students need to develop an understanding of engineering problems and learn what theories that can be applied on those problems. These are central competences for engineers. Accordingly is a capability to analyse those problems an important engineering competence. So if experiential learning in general is a useful theory and model for learning in Higher Education the very training of engineering competences are imbedded in this approach. Thus, for that reason it's crucial to use it as a foundation for teaching in engineering education. Many attempts to but experimental learning in focus for engineering education are also made. Some of the communities that try to strengthen this development towards experimental learning in Engineering Education and use it as the theoretical paradigm are SEFI, Active Learning in Engineering Education (ALE) and the CDIO initiative. CDIO describes the engineering working process of problem solving and stands for that an engineer conceive a problem, designs a solution, implement the solution and operate it in for example industry processing. The very meaning of the CDIO initiative is to use the engineering problem solving and working process as a teaching framework within Engineering Education. An essential building

block in the teaching paradigm of CDIO is experiential learning [9]. In all those communities that work intensely with the development of Engineering Education globally is experiential learning recognised as an important part in order to educate engineering students in a way that give them the required competences as future engineers. Even if there seems to be good reasons for trying out teaching methods in Engineering Education the teaching are developing in a slow pace and many prefer to stick to the old teaching traditions with a strong focus on lecturing and structured exercises. In order to support the assimilative process of learning this are adequate methods to choose but in order to enhance engineering students problem solving skills and development of engineering competences more active learning methods can preferable be considered. Also in order to help the students in the important process of accommodation in order to reach deep learning active learning methods are very useful. Experiential learning combines all the important traits in teaching for learning and if teachers in Engineering Education can be convinced to convert their teaching into this learning paradigm much can be won on the behalf of student learning.

1.2 Prerequisites for teaching and learning in Higher Education

There are a multitude of reasons why university teachers can be reluctant to change their teaching practice. The traditions in how teaching at university are supposed to take place are strong and there are some clear expectations that at a university you are listen to the biggest experts and authorities in a subject and take part of their knowledge in that way. Faculty has succeed within this system and are for that reason both reluctant and worried to change what can be perceived as a successful system that has been working for hundred of years. One central reason can be that faculty chooses a career at university for the reason that they are skilled on a very high level scientifically within a field and good researchers. Once they get a position as an associate professor they also have to teach and hopefully develop an insight that teaching also is a part of their profession. This development is often problematic for the reason that all rewarding systems at university acknowledge only research neglecting that a university has two main tasks, research and teaching. Through both those tasks universities provide the society with knowledge for the benefit of everyone in the society. It's not a given fact that faculty are posses the right competences to teach in a way that really support learning among the students [10]. Many university teachers institutively develop a way of teach that helps the student learn as their experience with teaching grows. Some university teachers in this process develop a deep interest for learning and seek competence development and knowledge about teaching and learning in Higher Education of own accord. Others can through out their careers experience difficulties to motivate the students to study and learn in their courses. This creates a downward going spiral that gives teaching a bad reputation of being a burden on researchers consuming time from the important research.

If knowledge is spread among faculty how to teach to support learning and if attempts to systematic provide university teachers with training in teaching and learning things much can be won [10]. When learning is going better among the students both the students and the teachers are more satisfied. Teaching becomes less time consuming and more interesting for everyone involved if active learning methods are used that support the learning process in a better way.

1.3 Principles in Teacher Training

In order to ensure a useful outcome of teacher-training programmes to truly support faculty to try out and implement active learning methods, the design of those programmes must meet the prerequisites that surround teaching in Higher Education. Hench, in order to succeed in motivating and attracting university teachers to participate in teacher training and take it seriously must the methods and processes in such programmes must be considered carefully. Time and usefulness are important factors to consider. Teacher training programmes need to be time efficient, still have an interesting and well considered content that are more or less directly applicable to teaching practice. Regarding Engineering Education it must be acknowledged that teaching and learning spring from a different research paradigm than the positivistic that are predominant in science and engineering. This gives reasons for doubt among engineering faculty for the reliability and trust worth of what is stated as true in teaching and learning. Often the tradition for teacher training follows two different strategies. The first strategy is that teaching and learning development unities at a university with a staff that are experts in teaching and learning runs courses for faculty. The second strategy is that faculty

themselves run activities at departments with focus on teaching and learning [11]. Both those overall strategies have advantages and pitfalls. In the first strategy an updated and scientific grounded knowledge base is provided but the content risk to be to abstract in relation to teaching practice. In the second strategy the advantage is that the activities to support teaching development are close related to teaching practice and the disadvantage is the lack of disciplinary expertise to ensure the accuracy of the content in those activities and a lack of broaden perspective on teaching and learning. In both of these strategies the issue of transfer of knowledge from one learning context to another is a crucial fact to consider in teacher training as well as in other learning situations [11]. Probably the best way is to work in a combination of both those strategies where for example an educational expert works as close as possible to the teachers' teaching practice. In courses and programmes it's helpful to use the faculties own courses and teaching practice as an object to relate the theory from teaching and learning to.

A combination of including teaching practice and the use of the theories and methods from the research field of teaching and learning that are proven to work to support learning makes an efficient learning context in teacher training programmes. Often those theories and methods are a part of the course content and to get the participating faculty a concrete experience of what those methods are creating for a kind of learning context and how the learning experience is working makes it easier for faculty to understand how the methods can be applied in their own teaching. This way to work supports the credibility for what is claimed as working in teacher training courses. When faculty in a systematic way learn to reflect upon this concrete experience of learning we approach the use of active learning methods based on the process that builds on the Kolb learning circle also in teacher training. This can be a source of inspiration and motivation for faculty to try those methods themselves.

2 BASIC TEACHER TRAINING AT DTU

The Technical University of Denmark is a polytechnic university with about 10.000 students and 2500 in staff. At DTU there is created an ecosystem for teaching and learning development with pedagogical coordinators and educational supervisors at every department. The core in this ecosystem is the teacher training programme Education in University Teaching at DTU – UDTU, mandatory for everyone applying for a position as an associated professor at DTU. The education has being running in its present form since 2004 and there are 72 participants each year following the education, divided into two teams. UDTU is a practical education in teaching at university level. The emphasis is on topics which are important for planning, implementing, evaluating, and understanding teaching and assessment with focus on student learning in engineering education in general and at DTU in particular. The overall objective of UDTU is to develop knowledge, methods and tools to make faculty able to conduct teaching at university level proficiently and to make them able to continually develop their teaching practice and understanding of student learning at university level.
The learning objectives of UDTU that the participants are supposed to be able to
- set up learning objectives for a course in order to support the development of engineering competencies
- identify core elements in a course related to the learning objectives
- plan a course with teaching and assessment methods that focus on the learning objectives and encourage deep approach to learning
- test students' pre-knowledge and learning outcome
- use feedback from students and peers to develop your teaching
- use teamwork and peer coaching to develop your teaching
- analyse the impact of teaching and assessment on student learning
- use this analysis to develop your teaching and your understanding of teaching and learning.

The educational scientific foundation in UDTU is constructivism and phenomenography. Furthermore UDTU is based on active learning and in-action research and the participants will learn about university teaching by working with the development of their own teaching. The education consists of a sequence of 4 modules. The first three modules all contain pre-assignments and one seminar each. The fourth module consists of a larger project on teaching development based on a course that the participants teach themselves.

UDTU has over the years been an important driver for teaching development at DTU. Therefore head of departments and DTU management expressed a wish that an equivalent education should be created for experienced teachers with the same objectives and with a design that could meet their comprehensive experience from teaching. In order to meet this demand, the principles known to support efficient teacher training and in an efficient way make the participants understand constructivism and active learning based on experiential learning the course design was based on the Kolb learning circle in its pure form starting in the phase of Concrete Experiences. The participants start UP with analysing their own teaching practise and with scrutinizing their students' learning. By staring in this way our belief is that the participants become motivated to understand more about their own teaching practice and to learn more about teaching and learning to overcome challenges they perceive. The education process becomes their own.

2.1 Course Design "University Pedagogy" for experienced teachers

"University Pedagogy" (UP) is an education for experienced teachers at DTU who wish to work systematically with the development of their understanding of university teaching and how students learn. The education has content and form tailored to experienced teachers and the workload is estimated to be 140 hours. UP will enable the participants to document teaching and learning outcomes and to reflect upon the obtained results in order to increase their understanding of the relation between their teaching and their students' learning, and to disseminate this knowledge on a theoretical basis. UP has by and large the same learning objectives as the educational program for new faculty members at DTU, UDTU, and provides the same qualifications. The aims of UP are that the participants

1. Acquire research-based knowledge of university teaching; education and learning so that they can develop their teaching practice and enhance their understanding of university teaching.

2. Plan and start the development of own teaching practice, e.g. a course revision.

3. Meet DTU educational key persons and build a network of dialogue partners in university teaching.

4. Learn the terminology related to teaching and learning at university level that colleagues who have participated in the educational program for new faculty members (UDTU) apply.

The central ideas in UP education are to take the departure the participants' teaching practice and to base the course design on Kolb learning circle. The process starts with the phases of Concrete Experience and Reflective Observation where UP opens with discussions, exploration and analysis of the participants own practice. Thereafter follows introduction to teaching and learning theory, theory and methodology for course planning, the orchestration of learning, assessment and research-based teaching in the phase of Abstract Conceptualisation. Through the education each participant prepares a proposal for revision of his or hers course where they apply the theory and operate with their course in a new way. This activity corresponds to the phase of Active Experimentation in the learning circle. To finalise UP each participant presents an implementation plan for the course revision and receive individual feedback and coaching from an external expert in the field of university education, primarily focused on engineering education. Here the participants again return to the phase of Concrete Experience and get a new experience of their courses which gives new reasons for Reflective Observations. Hence, a learning loop about teaching and learning practice evolves. Figure 1 shows the Kolb learning circle and the chosen overall teaching means (shown in red) of the teacher-training programme.
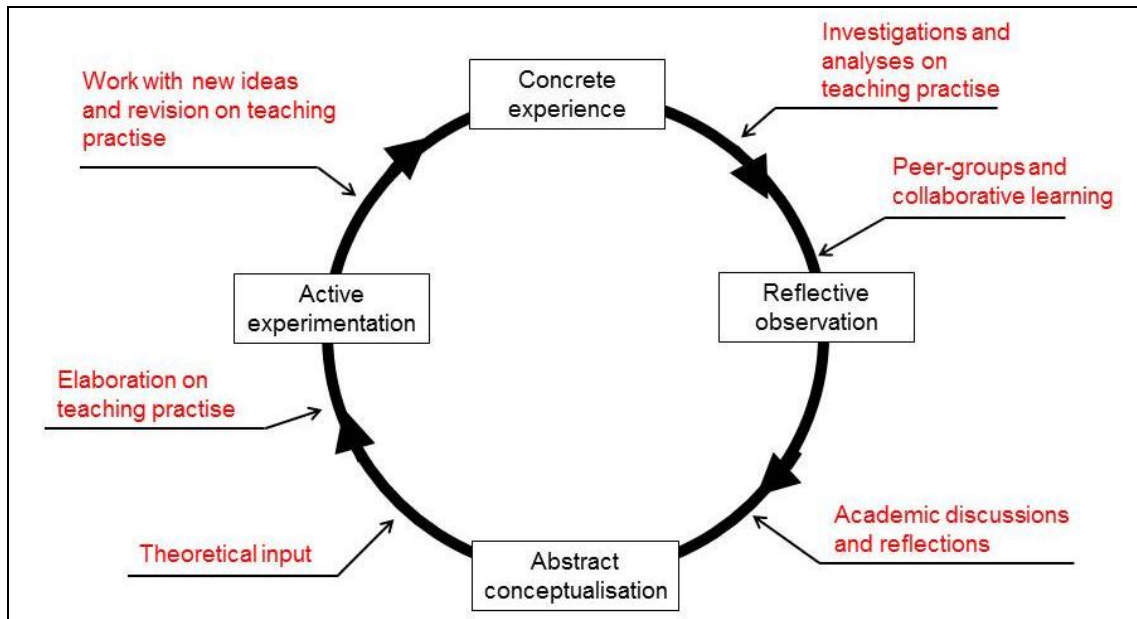
Figure 1. The Kolb learning circle and the teaching means of the teacher-training programme.

3 JUSTIFICATION OF THE USEFULNESS OF THE COURSE DESIGN

A course evaluation was carried through after the course. The participants were to respond to the questions in Table 1 and also answer some free text questions i) Which part of UP did you learned most from? ii) Which part of UP did you appreciated least and what were you missing? iii) This was the first time UP was held: Do you have suggestions for improvements? iv) We have tried to design UP after the Kolb model for experiential learning. Can you please shortly describe how you have experienced the working process in UP. In all there where 16 participants and 14 responded to the evaluation. The results for the evaluation statement using the Likert scale are presented in figure 2. The overall picture from the results of the Likert scale is that the participants are satisfied with the education and that it to some extent has been useful for their development as university teachers.

Table 1. EVALUATION QUESTIONS

|	Question	Scale 0, 1, 2, 3, 4, 5
	Question	Scale 0, 1, 2, 3, 4, 5
Q1	How was your overall outcome of UP?	0: Unsatisfactory – 5: Excellent
Q2	Did you gain new methods, knowledge and insights about teaching and learning in UP?	0: Not at all – 5:Yes, to a high degree
Q3	Were the topics in UP relevant for your development as a university teacher?	0: Not at all – 5:Yes, to a high degree
Q4	Do you think UP will be useful for your teaching and your students' learning in the future?	0: Not at all – 5:Yes, to a high degree
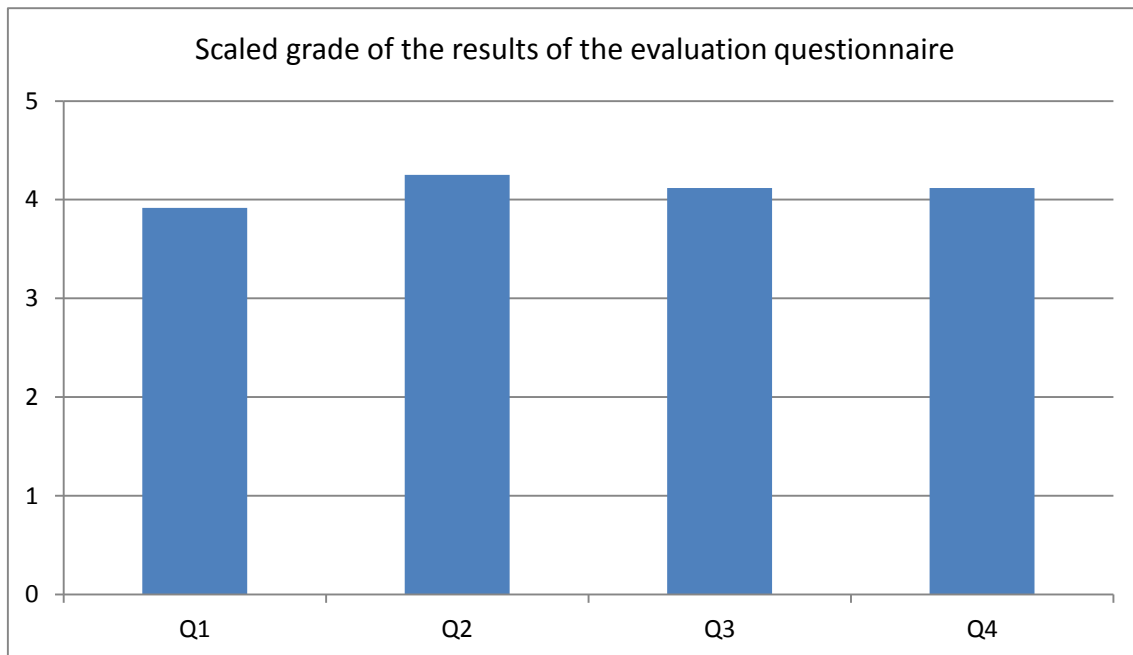
Fig.2: Scaled grade of the results from the evaluation questionnaire.

The free text question that interested us most is the one that addresses how the participants experienced the working and learning process following the Kolb learning circle. All the participants that responded to the evaluation state that the liked the process and learned from it. Some also describe that they appreciated the circular process and that it was useful for their learning and understanding and that they returned to subjects on a more advanced level throughout the education. One participant wrote "I will try to keep the loop going". Overall it seems that the process has been working as a course design to facilitate learning. The most important issue is if UP has had an impact on the participants' teaching practice with respect to implementing active and experimental learning in the courses at DTU. Of course it is a bit early to say something qualified about the results with respect to this. Though, some observations are already made i) One participant has implemented Problem Based Learning pure form in one course with good success ii) One participant that for many years have received low results on course evaluations from the students has gotten better evaluation after experimented with case based learning and reduced the time lecturing iii) One participant has implemented inquiry based learning in an introduction course to nanotechnology. Other results reported from the participants are that they think they understand their teaching practice much better after UP, that they are more professional as university teachers and that they can challenge their colleagues to start to develop and experiment in their teaching.

4. SUMMARY AND CONCLUSIONS

To sum up the experiences from this try out to use the methods in a teacher training programme that we would like the faculty develop and use in their own teaching it seems like it work fairly well. It has been very interesting to try Kolb learning cycle and experiential learning in its pure form. It work very well and it was very helpful in the designing of the course. At first we very a bit worried that the busy faculty would find it a bit waste of time to spend the two first course days elaborating and analysing their own courses, teaching and students but very soon we realised that this was a very useful process. In the end of it the participants themselves started to ask for the answers to meet the challenges they found out about in their courses after having interviewed their students and what they could do. Hence, they were motivated to open up for the theory about teaching and learning in Higher Education instead of going to defence mode for being challenged in their understanding about how learning occurs after many years of practicing teaching. Remained to investigate is the long term

effect of UP in the teaching practise at DTU and to see if the process run as smoothly in future teacher groups that will participate in the education.

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