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Does Pedagogical Training Benefit the Engineering Educator?*

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This paper presents the goals of the teacher training programme for newly recruited engineering educators at two polytechnics in Finland, namely Tampere Polytechnic, Tampere, and Helsinki Polytechnic, Helsinki. This training is compulsory for the engineering educators of the BSc level. Some theories on teaching and learning styles are described in the paper and, on basis of the authors' long experiences as teacher educators in the field of engineering education, these have been integrated into the authors' teaching practice. The concept of the pedagogical content knowledge is described and applied. Some details of the teaching practice, as well as some of the benefits the newly recruited teachers derive from it, are also described.

INTRODUCTION

In Finland, engineering education is given at universities and polytechnics. Students at universities get an MSc degree of 180 credit units and at the polytechnics a BSc degree of 160 credit units. The Finnish education system gives one credit unit (1 cu) for an input of approximately 40 hours of study work. This includes both attending lectures and independent study time. One credit unit is equivalent to 1.5 ECTS (European Credit Transfer System) [1].

In Finland, there are about 5,000 students starting their engineering studies at the MSc level and 8,000 students at the BSc level annually. There are 5.2 million inhabitants in Finland, meaning that there is a starting place reserved for about 20% of the age group.

The percentage of dropouts at the MSc level has been about 30% and at the BSc level about 10%. There is concern that these figures might be ascending. The places reserved for engineering studies have been planned to be sufficient for Finnish industry and commerce. However, the figures do not leave space for dropouts. Students dropping out are also a waste of both educational resources and the students' resources as they have spent time without achieving results.

With the amount of students being so large, it is clear that the groups are very heterogeneous. This being the case, the education programmes and teaching methods have to be planned in a way where all students can be helped and motivated to finish their studies.

One reason for dropping out is the lack of technical capabilities, but probably more often it is the lack of motivation or maybe even lack of self-esteem when tackling engineering and science subjects. Many young people of today do not find engineering or science subjects attractive. Indeed, this seems to be a common problem in many industrial countries. The ability to cope with new learning theories and master new teaching methods can present a solution in gaining better learning results and motivation.

TEACHER TRAINING

The requirement for Finnish polytechnic teachers is that they have at least an MSc degree. In the field of engineering education their major has to be in the

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subject they teach and a minimum of three years of industrial experience is also required. It is not uncommon that the teachers have a doctoral or licentiate degree and/or industrial experience of 10-15 years. All members of the polytechnic teaching staff are required to have a formal pedagogical education and training of at least 35 credit units. The training is most commonly carried out as an in-service training after nomination at one of the five Teacher Education Centres in Finland.

In the recruitment of university teaching staff, no pedagogical skills or formal teaching qualifications are required. In fact, the discussion and the need to pay attention to candidates' pedagogical skills when appointing professors started only a few years ago [1-3].

The aim of the teacher education programme for engineering teachers is to give a versatile pedagogical competence and initiate a process where the newly recruited educators can develop from a teacher trainee to a self-directing professional. The teacher education programme is planned to give deeper insight into modern learning theories and theory application in order to get the best possible learning results for students of engineering [4][5].

The newly recruited teachers at Finnish polytechnics have broad and solid expertise in their field. They can also be familiar with different methods of training people but they usually lack knowledge in modern learning theories and the wide variety of teaching methods available, such as those supported by the constructivist learning theories [6]. Thus, the new teachers are in need of the support of pedagogical theories.

It is obvious that professional learning must always be connected to context. It is therefore of great benefit for teacher trainees to be able to get their teacher competence as an in-service training. The acquired pedagogical knowledge can be directly applied to praxis. This gives a strong basis for building the subject matter knowledge into pedagogical content knowledge and also gives the opportunity to develop the skill to reflect.

Theories for Teaching Practice: Teaching and Learning Styles

All teachers have their own personal theory of teaching and learning. The basis for this personal view originates in the individual's knowledge of human nature and concepts of learning and knowledge. It is obviously very much influenced by former experiences as learners and maybe also teachers. As educators, we have learned much by watching others.

One of the aims of teacher education is to introduce the teacher trainees to various teaching methods and learning styles and in this way influence their concepts of learning and teaching so that they can obtain useful tools to develop their own personal views and styles. The teaching-learning situation is always very complex. There is no one situation exactly like the other. Developing a personal theory step by step will help teachers understand more about education and is a sign of professional growth.

Theories of Teaching

Dennis Fox [7] introduced his four theories of teaching almost 20 years ago. Since then, his question *What do you mean by teaching?* has been answered in many ways. The way a person answers this question reflects and influences the way in which that person tackles the job of teaching.

The transfer theory and the shaping theory are considered to be simple theories of teaching. The relationship between teaching and learning is straightforward; that what is taught is also learnt. The transfer theory is one adopted by many inexperienced teachers. Here knowledge is just treated as a commodity that can be transferred from the teacher to the student. An old-fashioned lecture can most typically be an example where the transfer method is commonly applied. A classical joke illustrates the transfer theory: *The notes of the lecturer become the notes of the students without passing through the minds of either*.

The shaping theory is respected by many behavioural psychologists and views students as raw material to be shaped or moulded. How the students turn out is predetermined and carefully specified. Shaping is achieved by showing and demonstrating, after which exercises are given along with precise instructions. The concepts of training and educating seem to mean the same thing for shapists. The shapists can also see their job as making connections in the students' minds.

Teacher educators have tutored many novice teachers leading their science laboratory classes, engineering workshops and problem classes amongst others, which are typical teaching environments of the shapists. The laboratory works and exercises will have quite predetermined outcomes. The instructions have been done with diligence and care, but they turn the experiments into routine measurements where there is not much place for self-direction, innovation or creativity - features that are most desirable in today's engineers.

The travelling and growing theories are the more developed theories of teaching introduced by Fox. These theories have features of the more modern constructivist learning theories as the students are viewed as contributing partners of their own learning. In the developed theories, the students are individuals with valuable experiences and abilities, motives and objectives. The preconceptions of the students, some of which are misconceptions, are acknowledged as having an important role in the learning process of the students [8-10]. These developed theories are more typically held by experienced teachers.

The travelling theories are more commonly adopted than the growing theories. Travelling theories, and also transfer theories, are said to place more emphasis on the subject. In Fox's travelling theory education is seen as a journey and the subject studied represents one of the many interesting and challenging areas to be explored. The difficulties of different subjects are described by small hills and huge mountains that have to be climbed. But the higher one climbs the better the view. For example, in the teaching of sciences that have a large factual content, the travelling theories are popular amongst experienced teachers. The teacher is the local guide, is experienced and enjoys sharing his/her experiences with the students. The teacher provides travelling equipment like maps and compasses.

Fox states that *no guide though, no matter how competent or experienced, can do your exploring for you. Exploration is a personal activity.* This describes well the constructivist view of learning theories. The students' valuable experiences and abilities, motives and objective are also taken into account.

The growing theory is referred to as a garden covered with vegetation. In this analogy the preconceptions of the students can be found in the variety of plant species. The gardener has to take into consideration the existing vegetation when he/she wants to cultivate a part or some species of the garden. In spite of what the goal is, which plants to cultivate, the weeds or misconceptions have to be extinguished. Many articles discuss the problem of uprooting misconceptions and altering conceptions and it is often pointed out that this is not an easy task. Usually people tend to fall back to their deeply rooted ideas after some time has passed [11][12]. However, there are also opinions that this is not worth the effort and that it is useless to try to achieve conceptual change in students. It would be wiser to add new scientific concepts to the everyday concepts the students already possess and to explain when to use which set of concepts [13].

Both developed theories place the teacher in a more human and responsive role, than that of a provider of information or shaper of inert material. The travelling theories seem to place more emphasis on the subject. Growing theories, similar to shaping theories, seem to place greater emphasis on what is happening to the student as a person. Although the more simple theories of teaching are criticised, they also have their place in education.

An experienced teacher knows the pros and cons of several methods and is able to choose the most suitable method for the subject and topic. One of the goals of the teacher education is to assist the teacher trainee to learn how to make good and successful choices.

LEARNING STYLES

The classical works of John Dewey, Kurt Lewin and Jean Piaget describe the process of experiential learning. From the basis of their work, David Kolb proposed a model of a typology of individual learning styles and corresponding structures of knowledge [14]. The definition for learning is presented as a process whereby knowledge is created through the transformation of experience. Knowledge results from a combination of grasping experience and transforming it. The grasping can be done via apprehension or comprehension and the transformation via extension or intention. This results in four different elementary forms of knowledge, namely: convergent, divergent, assimilative and accommodative.

There is variability and individuality in the learning processes of human beings. The Learning Style Inventory (LSI), as described by David Kolb, was created to assess individual orientations towards learning. It describes how you learn, how you handle your ideas and everyday situations of your life. The process of experiential learning can be described as four adaptive learning modes, which are concrete experience, reflective observation, abstract conceptualisation and active experimentation.

Kolb's Four Basic Learning Modes

People with *concrete experience* orientation focus on experiences and deal with immediate human situations in a personal way. They function well in unstructured situations and have an open-minded approach to life. In dealing with problems, they base their solutions on feeling rather than thinking. They take an intuitive approach over a systematic or scientific one.

People with a *reflective observation* orientation understand ideas and situations by observing and

describing them. They prefer understanding rather than being able to apply, they prefer knowing the absolute facts rather than how things work. They enjoy reflection rather than action and look at things from different perspectives and appreciate different points of view. They rely on their own thoughts and feelings to form opinions, value patience, impartiality and thoughtful judgement.

People with an *abstract conceptualisation* orientation use logic, ideas and concepts. They emphasise thinking rather than feeling. They prefer building general theories rather than intuitively understanding unique, specific areas. They solve problems with a scientific approach. They are systematic and like manipulating with abstract symbols and quantitative analysis. They value precision, the rigour and discipline of analysing ideas and neat conceptual systems.

People with an *active experimentation* focus on actively influencing people and changing situations. They prefer practical applications rather than reflective understanding and are pragmatically concerned with what works rather than the absolute truth of problems. They prefer doing to observing and get things accomplished and take risks to do so. They value being influential and getting results.

Most students do not fit exactly into any of the described learning modes but are a combination of two or more. As combinations of these learning modes, there are four different learning styles: convergent, divergent, assimilation and accommodative.

The strength of the *convergent* learning style lies on problem solving, decision making and practical applications of ideas. Convergent learners prefer dealing with technical tasks and problems rather than social and interpersonal issues. They rely on learning abilities of abstract conceptualisation and active experimentation.

The *divergent* learners have the opposite learning strengths from convergence. They view concrete situations from many perspectives. They prefer observation to action and enjoy generating ideas and implications. They engage in concrete experience and reflective observation, and their learning style emphasises concrete experience and reflective observation. They are interested in people and tend to be imaginative and feeling oriented.

In *assimilation*, the greatest strengths lie in inductive reasoning and the ability to create theoretical models. People are of less interest while ideas and abstract concepts are more important. The soundness and precision of an idea is more important than its practical value. The dominant learning abilities are abstract conceptualisation and reflective observation.

The *accommodative* learning style has the opposite strengths from that of assimilation. These learners do things, carry out plans and tasks and get involved in new experiences. They seek opportunities, take risks and prefer action. They tend to solve problems intuitively by trial and error. Concrete experience and active experimentation are the strengths of these learners.

PEDAGOGICAL CONTENT KNOWLEDGE

Lee Shulman has described the knowledge of a professional teacher or what the conception of teacher knowledge should encompass [15]. This includes a deep knowledge of the content and structures of the subject matter, the subject and topic specific pedagogical knowledge associated with the subject matter, as well as the curricular knowledge of the subject. Shulman introduced the concept's content knowledge of teachers, general pedagogical knowledge and pedagogical content knowledge. In the context of teaching, his content knowledge encompasses subject matter content knowledge, pedagogical content knowledge and curricular knowledge.

Shulman's criticism is that pedagogical knowledge is emphasised when discussing the skills of teaching and that not enough focus is given to subject matter knowledge [15][16]. The emphasis, no doubt, must be on subject matter knowledge in all higher education, and no less with engineering education. Nevertheless, the question must be asked: *You know it but are you able to teach it?* Teaching is much more than just transmitting knowledge.

Subject matter knowledge is one form of content knowledge and includes knowledge of the facts and subject content, including the major concepts of the field, the relationships among concepts and a full understanding of the structures of the subject [15][16]. In science and engineering education, this includes theoretical facts of phenomena and propositions and their justifications. The mastering of the applications

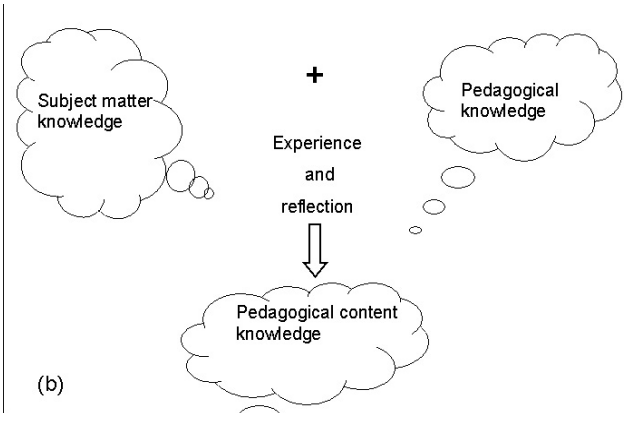

Figure 1: Structure of subject matter knowledge.

to everyday life and engineering is, of course, of crucial importance. The subject matter knowledge of an engineering educator should be built of, not only of academic studies, but also of a wide experience of working in the industry or as a researcher where the knowledge has been applied, proven and refined in practice (see Figure 1).

General pedagogical knowledge includes knowledge of the basic principles of pedagogy. It encompasses theories of teaching such as Fox [7] and learning such as Kolb [14]. These theories give tools for motivating students, preparing lectures, facilitating collaboration, using and developing various teaching methods and materials, student assessment, self-assessment and self-direction.

Pedagogical content knowledge can be described as subject matter knowledge for teaching. It includes aspects of content most germane to its teachability or, in other words, the ways of representing and formulating the subject that make it comprehensible to others [15]. Since no one can recommend just any single form of representation, the teacher must have at hand several alternative forms of representation, some of which derive from research, whereas others originate in experience (see Figure 2).

Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons. If those preconceptions are misconceptions, which they so often are, teachers need knowledge of the strategies most likely to be fruitful in reorganising the understanding of learners. Pedagogical content knowledge can simply be seen as encompassing subject matter knowledge and general pedagogical knowledge, with an emphasis on a broad description of subject matter knowledge [15].

The newly recruited teachers usually achieve their general pedagogical knowledge when attending the teacher education programme. They start developing their pedagogical content knowledge when they start teaching. The teaching practice period is especially planned to assist the teacher trainees to develop their pedagogical content knowledge and pedagogical skills. This process continues throughout their teaching career.

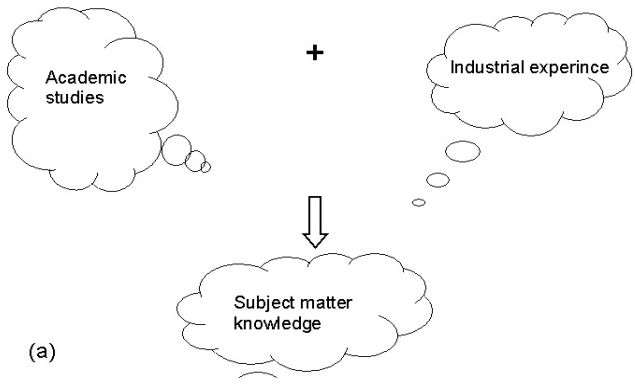

Figure 2: Structure of *Pedagogical content knowledge*.

Curricular knowledge encompasses the range of programmes designed for the teaching of particular subjects and topics. It tells how a special field is organised for instruction. It can also include knowledge about purposes, goals and rationale for a programme or course. [15][17]

DEMONSTRATION OF TUTORING AND PEDAGOGICAL CONTENT KNOWLEDGE

A teacher trainee-teacher educator situation will now be demonstrated and how tutoring will help the trainee in developing his/her pedagogical content knowledge. This will be presented in a dialogue incorporating three phases that deal with the teaching practice period.

Phase 1: the First Meeting

The following dialogue covers the first meeting between the teacher trainee (Samuli) and his personal teacher educator (Carina).

Carina: *Hello Mr Kolari, you wanted to discuss with me some things that have troubled you.*

Samuli: *Yes indeed!* (somewhat annoyed)
First of all I want to say that I don't have anything against you personally, and many things that have been lectured to us during the first days of our pedagogical training have been very interesting, but hardly helpful. The atmosphere has been very good and inspiring. But now I don't know what to do?

Carina: *Okay, what do you mean?*

Samuli: *I mean the realities of my life today. What on earth have you thought? How can I survive? When I try to prepare my lessons and do all my duties I just can't find the time and energy to cope with it all.*

Carina: *I can see your problem, I have experienced it myself and I suggest that you think…*

Samuli: *But dear Mrs Ranne! If I will teach like*

you want me to do, for example using student centred teaching methods, then most things which are in our curriculum have to be left out and I simply can't take the time to prepare my lectures with, for example, problem-based learning as a starting point.

Carina: *That's true, I propose that we have a meeting where we together can have a look at the curriculum in order to see what topics are essential and which have a good transfer effect, by which I mean topics which are useful and broadly applicable to engineering disciplines. I will also invite some of your older colleagues, if you don't mind. You will get a chance to discuss what concepts they have found difficult to teach and what teaching strategies they use. The students' preconceptions can be quite a surprise for you.*

Samuli: *It's fine with me, but in fact I know how to teach. I have had a couple of very skilful teachers in school and at my university. I can teach like they did; it's no problem. The problem is, how can I keep my knowledge up to date and deliver it to my students? I hardly have time enough to have a look at any weekly professional magazines, prepare my lessons, plan new courses and labs and so on.*

Carina: *You probably take on too many responsibilities. But maybe we can deal with this later when you show me some lesson plans. We have to keep in our minds that you must have your responsibilities and personal life in good balance. You can´t deliver your lectures if you are all worked out.*

Phase 1 Comments

At the beginning of his/her career and teacher training period, the newly recruited teacher is often somewhat confused and even a little desperate. There are so many things to learn and do when preparing lessons and performing duties. Usually the new teacher has all the same duties as a colleague who may have been teaching for 20 years. This is a special feature in this field of work, where a variety of subject matter topics have to be made comprehensible to the students, new teaching methods have to be adopted and practiced and a many administrative duties need to be done. This can be quite a threat to the enthusiasm of the teacher.

It is important that the teacher trainee and teacher educator take enough time to communicate. The teacher educator must certainly be sensitive and have the talent of listening; the teacher trainee's feelings and state of mind need to be perceived carefully. The teacher educator has to be able to motivate the trainee to pursue these new challenges. It is crucial that there is a good atmosphere and that the relationship between the teacher educator and the trainee is respectful and confidential. It is pointed out in many studies that the mutual discussions between the teacher educator and trainee have a strong influence on the professional development of the teacher [18].

When the teacher trainee receives his/her teacher education as in-service training at his/her own institution, it is possible to integrate this quite straightforwardly both to the teaching job and other duties in the faculty. Furthermore, it is preferable that the teacher educator is familiar with the subject being tutored. However, it is of crucial importance that also the older colleagues of the new teacher take part and cooperate if the teacher educator is not familiar with the subject.

The interpretation of the curriculum can be a mystery for someone who is not familiar with its vocabulary and tacit information, even if he has been working in this field of industry for several years. The help of the teacher educator and colleagues here is also very valuable. Everything cannot be taught and picking out the essentials can be difficult if attempted on one's own.

Phase 2: a Meeting Some Months Later

Samuli: *I will be teaching friction. This is how I have been taught and this is the way I will start out teaching it myself* (see Figure 3).

Carina: *Hmmm! Oh yes. It's neat. I can imagine how you will go about this. And whereabouts in your presentation do you suppose your students will find the answer to the question* Why don't nails pull out from the ceiling? *or* What is the idea of knots?

By the way, have you noticed that you have managed to get quite a lot of stuff on one transparency?

Samuli: *I hadn't thought about that.*

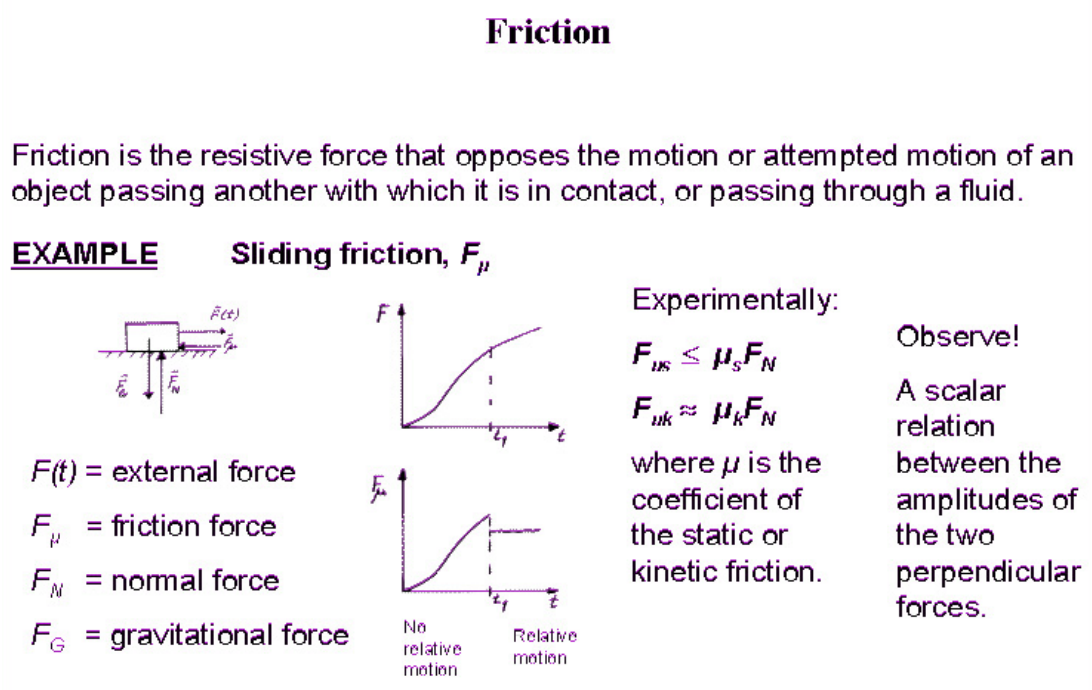

Figure 3: Traditional example of teaching friction. But will the students learn?

Carina: *So you actually think you must have time to pour all your knowledge into the students. That's nothing new for a novice teacher. Let's make some plans for you. What are the most important things that you want your students to learn? Why are those things so important? How can you explain those to your students? How have you learnt those things yourself?*

You probably remember what you were taught at the lectures of pedagogics earlier this fall dealing with different teaching and learning styles.

Samuli: *Do you mean for example teaching styles described by Fox and learning styles described by Kolb?*

Carina: *That's right. So, let's continue ...*

Phase 2 Comments

This is a typical situation where Fox's transfer theory is applied. The lecture is well prepared using overheads and with numerous propositions. However, the preconceptions of the students are given very little or no consideration and there is no effort to get any conceptual change in the students by stating *these are the facts and formulae; this is how things are*. Inexperienced teachers often prefer teaching methods that they liked most when they themselves were students [19][20].

The aim of the teaching practice is to try out the suitability of different teaching methods and pedagogical theories. Because there are so few articles on pedagogical applications to engineering subjects, the teacher educator often has to give some help by suggesting suitable pedagogical theories and approaches. After attending the teacher trainee's lectures, the teacher educator also helps by giving feedback and discussing the advantages and disadvantages of the approach chosen.

As the teaching practice period proceeds, more emphasis can be given on reflection and self-assessment. One of the difficulties the teacher educator often has to face is to convince the teacher trainee of the benefits of a constructivist approach to teaching and learning. Although the trainees understand the importance of an active role for the student, they still tend to believe that the most efficient way to teach is the traditional way of direct transfer. It is of course obvious that most material can be covered in this way. But how about learning?

The aim of teacher education and the teacher training period is not to advertise just some teaching styles or theories, but to introduce several theories and reflect on their advantages and disadvantages and to find the ones suitable for the subject and topic at hand that the teacher can feel comfortable with. Getting acquainted with various teaching and learning styles helps the teacher consider the possible reasons for unsuccessful learning. The teacher educator helps the trainee to see things from different perspectives. This

way, the actions of the trainee and his/her students can be analysed and evaluated by the trainee. This will help the trainee to find a reflective teaching approach. It has been indicated that a reflective teaching approach has a remarkable effect on the professional development of a teacher and the growth of his/her pedagogical content knowledge [21-23].

Phase 3: the Training Period is Nearly Over.

Carina: *Hello Samuli, how are you? How has your training proceeded? It will soon be over. How do you feel about things?*

Samuli: *Dear Carina, I must admit that the way I teach has changed in a direction that will probably please you.*

Carina: *How so? Can you give me some examples?*

Samuli: *I would love to do that!*

Do you remember when we discussed friction; you were right. I had depressing learning results. I asked a simple question from a typical engineering problem: How or why does a screw tighten and what things do you have to consider when you actually tighten a screw? *Hardly anybody knew the answer! The students had learned next to nothing!*

Carina: *And what did you do about it?*

Samuli: *I noticed that my students did learn the definition but the understanding of the true nature of friction, by which I mean real everyday situations, was very limited, inluding applications such as the friction brake, friction clutch, friction drive and belt conveyor.*

So, are you really interested and do you have time to listen if I tell you what I did about it?

Carina: *Yes, please show me!*

Samuli: *Nowadays I start by asking the following question:*

What will happen to the rod when the supports are slowly moved together so that they meet each other in the middle? (see Figure 4)

Then I will ask for their opinions. Usually all alternatives get support. Then we will have a discussion where students explain their reasoning for their choices.

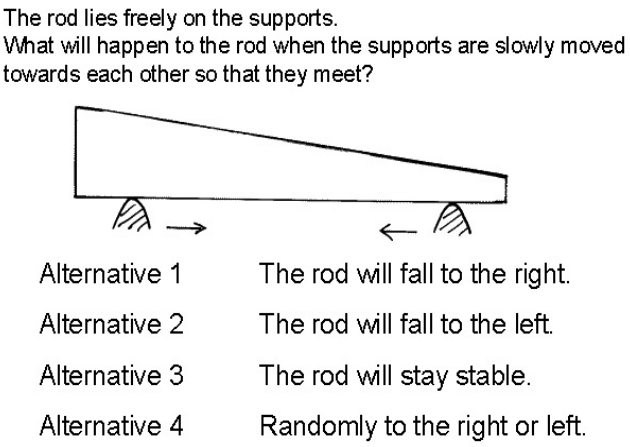

Figure 4: Revised example used to demonstrate friction to students.

In this way I can get information about my students; how they think and what kind of preconceptions they have. I can take these things into consideration when I next time teach the same subject. My students learn to justify their opinions and also to give consideration to others' opinions.

After the discussion, my students choose a volunteer and do this experiment on their own. We only need, for example, a wooden rod that is about 90-100cm long with a shape shown in Figure 2. The rod is laid horizontally on the forefingers. The hands are kept about 70cm apart from each other. Then hands are slowly moved towards each other so that the fingers meet exactly in front of you. It is important to concentrate only on moving the fingers slowly together in spite of how you feel. The students don't always follow the instructions, but when doing the experiment they will soon find out the reason for my precise briefing.

After this little experiment, we usually have a fruitful atmosphere for considering more successfully the influence of static and kinetic friction. With this experiment, we usually succeed in arousing a contradiction that causes motivation in the learner's mind. We can both feel and see what happens. This helps us understand the real feature of friction forces. I mean, for example, that you can feel that static friction is not a constant force; it is variable.

Furthermore, when they draw free body diagrams in different situations they

can realise which forces are variable and what force or which forces are constant. If my students are familiar with programming, they can make a simulation about this experiment.

So Carina, what do you say, am I on the right track?

Carina: *Oh yes, you certainly are. I hope that you have learned to enjoy your lessons and demonstrations. Even simple demonstrations are very educational and also lots of fun. We must just learn how to take advantage of them. This is very well in line with the constructivist learning theories that recommend personal evolvement and purposeful activities.*

Phase 3 Comments

When the students discuss and justify their decisions and opinions and explain how they have understood the problem and what solution they suggest, it creates a fruitful atmosphere also for conceptual change. It has been shown in many situations that it is very difficult to create conceptual changes in students [24]. The language of the fellow students is often easier to understand compared with the academic expressions or professional jargon that the teacher uses. The students get more self-confidence when experiencing success. The students are only able to discuss freely and say their opinions if the teacher has been able to create a respectful, trustful and safe atmosphere. Research and experiences like this helps the teacher develop and improve the teaching environment.

Friction is an everyday phenomenon that both teachers and students are quite familiar with, although there are many preconceptions related with friction. The teacher can learn a lot when the students are asked to write down or draw some of their ideas about, for example, static friction. The models the students use for their explanations are a useful aid when attacking the problem of teaching friction. Do the students use a concrete analogy model or some very detailed explanation, which often leads to difficult and complicated ways of dealing with the problem?

A familiar phenomenon like friction gives an excellent opportunity for the teacher to discuss the advantages of being able to model things for example in science and engineering problems. Friction is a very complicated phenomenon, where the explanations can be derived from the atomic bonds between nearby particles. The teacher decides on the basis of his/her pedagogical content knowledge with help of which the approach to the explanation of the nature of friction is modelled, as well as what kind of applications are chosen. Does the teacher choose a quantum mechanical model or is the analogy found with atomic bonds?

SUMMARY

Although newly recruited Finnish teachers have a good mastery of their special subjects, with a long experience of applying their academic knowledge, they will soon face the problem of turning their knowledge into an understandable language for the students. The job as an educator differs in many respects from an industrial career. The in-service training gives a good possibility to familiarise the new teacher with the educational life and efficiently integrate them into the teaching community. They can get acquainted with their polytechnic, its visions and missions. The teaching training period is a good induction period and an excellent opportunity to train different teaching methods in authentic situations and obtain feedback.

Fox says that a person who has reflected deeply on the teaching-learning process, and whose thinking has advanced from the constraints of simple theories to the broader perspectives of the developed theories, will be in a better position to choose the most appropriate approaches [7].

It is apparent that appreciation of, for example, Kolb's learning styles means that no one teaching style can serve all of the students. The large groups in engineering education today generate heterogeneity amongst the students. It can no longer be assumed anymore that all students represent just one learning style as it was some decades ago. Some other personality types in the engineering profession could be involved on top of the more familiar stereotypes. If these are the realities, then teaching styles need to be chosen that serve various students and several purposes. The constructivist approach gives space and opportunity for various learning styles. Reflecting over all these issues will promote the professional growth of the engineering educator and his/her pedagogical content knowledge.

A citation from Paul Ramsden's book *Learning to Teach in Higher Education* sums up the authors' potentially critical views on the problems of and solutions for engineering education today.

For too long we have relied in higher education on teaching that is essentially an amateur affair. A professional approach to teaching should be seen in the same light as a professional approach to law, medicine or engineering. ... It is not enough for a

lecturer to be an exceptional clinician, advocate, or designer. He or she must be a distinguished teacher as well. A distinctive characteristic of professionals is that they retain theoretical knowledge on which to base their activities. This body of knowledge is more than a series of techniques and rules. It is an ordered pattern of ideas and evidence that a professional teacher uses in order to decide an appropriate course of action from many possible choices [25].

REFERENCES

1. Eurydice. Two Decades of Reform in Higher Education in Europe: 1980 Onwards, National Description of Finland (2001), http://www.eurydice.org
2. Finnish Council of State. Asetus ammattikorkeakouluopinnoista (Decree on Finnish Polytechnic Studies) Op 237, **7,** 28 §, Helsinki (1995).
3. Galton, M. and Moon, B. (Eds), *Handbook of Teacher Training in Europe*. London: David Fulton Publishers (1994).
4. Teacher Education Centre, Tampere Polytechnic, Teacher Training Curriculum. Tampere, Finland (1997).
5. Kolari, S. and Savander-Ranne, C., Does the engineering educator need pedagogical training? *Proc. 4th UICEE Annual Conf. on Engng. Educ.*, Bangkok, Thailand, 370-373 (2001).
6. Kolari, S. and Savander-Ranne, C., Will the application of constructivism bring a solution to today's problems of engineering education? *Global J. of Engng. Educ.*, 4, **3**, 275-280 (2000).
7. Fox, D., Personal theories of teaching. *Studies in Higher Education*, 8, **2**, 151-163 (1983).
8. Pfundt, H. and Duit, R., *Bibliography: students' alternative frameworks and science education* (4th edn). Kiel, Germany: IPN at the University of Kiel (1994).
9. Viiri, J., Teaching the force concept: a constructivistic teaching experiment in engineering education. *European J. of Engng. Educ.*, 21, **1**, 55-64 (1996).
10. de Jong, O., Ahtee, M., Goodwin, A., Hatzinikita, V. and Koulaidis, V., *European J. of Teacher Educ.*, 22, **1**, 45-59 (1999).
11. Stavy, R., Using analogy to overcome misconceptions about conservation of matter. *J. of Research in Science Teaching*, 28, **4**, 305-313 (1991).
12. Burbule, N.C. and Linn, M.C., Science education and philosophy of science: congruence or contradiction? *International J. of Science Educ.*, 13, **3**, 227-241 (1991).
13. Sparkes, J.J., Learning-centred teaching. *European J. of Engng. Educ.*, 24, **2**, 183-189 (1999).
14. Kolb, D.A., *Experiential Learning*. Englewood Cliffs, N.J.: Prentice-Hall, 40-78 (1984).
15. Shulman, L.S., Those who understand: knowledge growth in teaching. *Educational Researcher*, 15, **2**, 4-14 (1986).
16. Soininen, M. and Iiskala, T., *Cross-Cultural Teaching and Learning: The European Dimension in In-service Teacher Training*. In: Langeland, K. and Sura, S. (Eds), The European Dimension in Teacher Education. Turku, Finland: University of Turku, Research Reports C:10 (2000).
17. Kreber, C. and Cranton, P.A., Exploring the scholarship of teaching. *The J. of Higher Educ.*, 71, **4**, 476-495 (2000).
18. Borko, H. and Mayfield, V., The roles of the cooperating teacher and university supervisor in learning to teach. *Teaching and Teacher Educ.*, 11, **5**, 501-518 (1995).
19. Kagan, D.M., Professional growth among preservice and beginning teachers. *Review of Educational Research*, 62, **2**, 129-169 (1992).
20. Stofflett, R.T., The ability to understand and use conceptual change pedagogy as a function of prior content learning experience. *J. of Research in Science Teaching*, 31, **1**, 31-51 (1994).
21. Schön, D.A., *Educating the Reflective Practitioner*. San Francisco: Jossey-Bass Publishers, 100-118 (1988).
22. Cervero, R.M., Professional practice, learning, and continuing education: an integrated perspective. *International J. of Lifelong Educ.*, 11, **2**, 91-101 (1992).
23. Clarke, A., Professional development in practicum settings: reflective practice under scrutiny. *Teaching and Teacher Educ.*, 11, **3**, 243-261 (1995).
24. Johnston, S., Conversations with student teachers – enhancing the dialogue of learning to teach. *Teaching and Teacher Educ.*, 10, **1**, 71-82 (1994).
25. Ramsden, P., *Learning to Teach in Higher Education*. London: Mackays of Chatham, 8-9 (1992).

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Conference Proceedings of the *5th UICEE Annual Conference on Engineering Education* under the theme: *Student-centred Engineering Education*

edited by Zenon J. Pudlowski

The *5th UICEE Annual Conference on Engineering Education*, under the theme of *Student-centred Engineering Education*, was organised by the UNESCO International Centre for Engineering Education (UICEE) and was held over the Internet and in person at Anna University, Chennai, India, between 6 and 9 February 2002. This volume of Proceedings includes papers submitted to the Conference and offers a manifold collection of almost 50 papers detailing various international approaches to engineering education and specific activities.

The Conference theme, *Student-centred Engineering Education*, was chosen to identify and present best projects, programmes and examples relevant to the main theme and to discuss their impact on the status and quality of global engineering education. Although the Conference s emphasis was on this theme, the papers included in these Proceedings present many aspects of engineering education and industrial training, addressing topics of vital importance to engineering education. These have been placed into various groups, namely:

- Innovation and alternatives in engineering education
- Important issues and challenges in engineering education
- New trends and approaches to engineering education
- Quality issues and improvements in engineering education
- Learning strategies and methods in engineering education
- Course development in engineering education
- International examples of engineering education and training
- Multimedia and the Internet in engineering education
- Case studies

Several papers in the Proceedings demonstrate research and development activities from within India and illustrate that the global debate on engineering education and the international expansion of interest in engineering education has grown and is having an increasing influence on the host nation.

In order to ensure their high quality and the value of the Proceedings for the future, all papers have undergone assessment by independent international peer referees.

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