CONTEMPORARY TEACHING METHODS EMPHASIZING CONCEPTUAL UNDERSTANDING ADAPTED FOR ENGINEERING EDUCATION AT ESTONIAN CENTRE FOR ENGINEERING PEDAGOGY

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Abstract

Engineering educators should gain greater confidence through the use of extended range of contemporary teaching tools by obtaining specifics of the art of teaching. Teaching methods fostering active and long-term engagement with learning tasks are used at Estonian Centre for Engineering Pedagogy. Understanding student different learning styles is one of the midpoints of teacher training. The aim of the study programme for engineering educators is to abolish mismatches between students' common learning styles and traditional teaching styles of engineering educators. The curriculum for engineering educators concentrates on interactive lectures and contemporary teaching methods emphasising conceptual understanding, adapted specially for engineering education, being introduced in the following article.
Key words: *interactive lectures, learning styles, teaching methods, engineering education.*

Introduction

Engineering educators are usually highly qualified in the field they work in, having enough experience which enriches their lessons and being able to provide students with practical examples. But they often lack education in teaching profession.

A highly specialized engineer often concentrates on the topic not taking account of the basic rules and principles necessary to be applied in all phases of the educational process starting with handing on information to students, practicing and testing new knowledge, motivating students during the whole process, choosing appropriate teaching methods etc. Each of these phases contributes to the whole process in a special way – none of them may be omitted. If so, it influences the quality of engineering education.

In 2006 only 20% of engineering educators at Estonian institutions of applied higher education (technical schools of lower tertiary level) had academic engineering education on Master level in engineering specialty they teach. According to Estonian legislation regulating education, 75% of engineering educators at technical schools of lower tertiary level should have at least Master degree. Today about 50% of teaching staff at technical schools having a part-time workload has been "borrowed" from the universities. Additionally retired university professors are employed. Great deficiency of engineering educators at technical schools of Estonia is amplified by the fact that 40% of them have already reached retirement age (Rüütmann, 2007).

These factors led to establishing new study programme in this field at Estonian Centre for Engineering Pedagogy at Tallinn University of Technology.

The Curriculum for Engineering Educators

The curriculum for engineering educators on Master level was completed in 2006 at Estonian Centre for Engineering Pedagogy. The curriculum was designed taking account of the most popular and perspective branches of industry in Estonia. Eight possible specializations were proposed: Civil Engineering, Power Engineering, Geological Technology, Information and Communication Technology, Chemical Engineering and Material Technology (including Wood Processing, Food Engineering, Textile and Garment Engineering), Logistics, Mechanical Engineering, and Technical Physics.

As the required entrance qualification of the candidate is Master degree in engineering and professional experience for at least one year, it is assumed that the candidate has already acquired knowledge in engineering speciality on high level. Students – future engineering educators, possessing Master degree in engineering already, are positive examples of lifelong learning.

The curriculum is based on IGIP (International Society for Engineering Education) Recommendations for Studies in Engineering Pedagogy Science, taking account of the main aspects of Klagenfurt School of Engineering Pedagogy founded by Adolf Melezinek (Austria) (Melezinek, 1999) and has been accepted and registered by Estonian Ministry of Education and Research. The curriculum is the only and the very first one in Estonia providing education in Engineering Pedagogy for engineering educators on Master level in the amount of 60 ECTS (European Credit Transfer System) credits.

The interdisciplinary scope of the curriculum could not be squeezed into one conventional university department and corresponding engineering faculties of Tallinn University of Technology were all involved in the implementation of the curriculum (Rüütmann & Vanaveski, 2008). 23 professors, involved in the study programme, possessing PhD degree have passed the relevant international courses at Estonian Centre for Engineering Pedagogy and have been awarded the title of International Engineering Educator.

The following subjects are included in the curriculum: Engineering Pedagogy Science in Theory and Practice, Laboratory Didactics, Psychological and Sociological Aspects, Rhetoric and Communication, Understandable Text Creation – Scientific Writing, Working with Projects: Curricula, Media (Teaching Technology) and E-Learning, Informatics, Product Development and Innovation, Standards Qualification and Certification, Teacher Training Practice, and Elective Engineering Speciality Subjects.

The first 24 students were admitted to the course in January 2007, 4 of them chose the field of Mechanical Engineering, 9 – Chemical Engineering and Material Technology, 1 – Civil Engineering, 3 – Logistics, and 7 - Information and Communication Technology.

In September 2007 additionally 22 students were admitted to the course, two of them already possessed Doctoral degree in engineering. Of 22 admitted students 2 chose the field of Logistics, 2 – Technical Physics, 1 – Power Engineering, 6 – Chemical Engineering and Material Technology, 5 – Information and Communication Technology, 4 – Mechanical Engineering, and 2 – Civil Engineering.

In September 2008 there were admitted 22 students three of them already possessed Doctoral degree in engineering. Of 22 admitted students 1 chose the field of Power Engineering, 5 – Mechanical Engineering, 3 – Civil Engineering, 4- Logistics, 5 – Information and Communication Technology, 2 – Technical Physics, 2 – Chemical Engineering and Material Technology.

Henceforth every year at least 22 students will be admitted to the course. As the practice of Estonian Centre for Engineering Pedagogy shows there is a wide interest towards the described Master courses and interest will remain high as there are no other appropriate courses in Estonia today.

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Theoretical and Methodological Aspects of Students' Different Learning Styles

Learning styles are characteristic cognitive, affective, and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. Students learn best when instruction and learning context match their learning style.

Understanding students' different learning styles is one of the midpoints of teacher training. The aim of the study programme for engineering educators is to abolish mismatches between students' common learning styles and traditional teaching styles of engineering educators and make teaching in engineering more effective, to equip future engineering educators with the skills associated with every learning style category, regardless of the students' personal preferences, since they will need all of those skills to function effectively as professionals.

Engineering educators should attempt to improve the quality and efficiency of their teaching, which in turn requires understanding the learning styles of engineering students and designing instruction to meet them. The problem is that two students are never alike. They have different backgrounds, strengths and weaknesses, interests, ambitions, senses of responsibility, levels of motivation, and approaches to studying.

According to Richard M. Felder (1993) students learn in many ways – by seeing and hearing; reflecting and acting; reasoning logically and intuitively; memorising and visualising; drawing analogies and building mathematical models. Teaching methods also vary. Some educators lecture, others demonstrate and discuss; some focus on principles and others on applications; some emphasise memory and other understanding. How much a student learns in a class is governed by student's ability and prior preparation, but also by compatibility of student's learning style and the instructor's teaching style.

Mismatches exist today between common learning styles of engineering students and traditional teaching styles of engineering professors. Most engineering students are visual, sensing, inductive, and active, and some of the most creative students are global, but most engineering education is auditory, abstract (intuitive), deductive, passive, and sequential. In consequence students become bored and inattentive, do poorly tests, get discouraged, and in some cases change to other curricula or drop out of school (Felder, 1993).

At Estonian Centre for Engineering Pedagogy the study programme for engineering educators is based on Felder-Silverman learning and teaching style model for engineering education (Felder 1988). The future engineering educators get acquainted with following different learning styles of engineering students: *sensing/intuitive learners* (sensing learners like facts, data, and experimentation; intuitive students prefer principles and theories); *visual/auditory learners* (visual learners prefer sights, pictures, diagrams, symbols; auditory learners – sounds and words); *inductive/deductive learners* – induction is a reasoning progression from particulars (observations, measurements, data) to generalities (governing rules, laws, theories); deduction proceeds in the opposite direction; *active/reflective learners* (active experimentation involves doing something with the information: discussing it or explaining or testing; reflective observation involves examining and manipulating the information introspectively); *sequential/ global learners* (sequential learners learn in a logically ordered progression, global learners learn in fits and starts: they may be lost for days or weeks, until suddenly they "get it").

According to Richard M. Felder (1993) an engineering student's learning style may be defined by the following methodology, answering to five questions:

1. What type of information does the student preferentially perceive: *sensory* (external) –sights, sounds, physical sensations, or *intuitive* (internal) – possibilities, insights, hunches?
2. Through which sensory channel is external information most effectively perceived: visual – pictures, diagrams, graphs, demonstrations, or *auditory – words,* sounds?
3. With which organization of information is the student most comfortable: *inductive –facts* and observations are given, underlying principles are inferred; or *deduc*tive –principles are given, consequences and applications are deduced?
4. How does the student prefer to process information: *actively* – through engagement in physical activity or discussion, or *reflectively* – through introspection?

5. How does the student progress toward understanding: *sequentially – in* continual steps, or *glob*ally – in large jumps, holistically?

Analysis of the students' learning styles at Estonian Centre for Engineering Pedagogy has been carried out according to above introduced methodology created by Richard Felder (1988, 1993).

As the result of the analysis, the future engineering educators, students studying at Estonian Centre for Engineering Pedagogy, were classified as follows: of the analysed 68 students, 61% were classified as active learners, 39% were classified as reflective learners, 64% were sensing learners, 30% were intuitive learners, 87% were visual learners, 15% were verbal learners, 55% were sequential learners and 34% were global learners.

As the results of the analysis present, 64% of students were sensors, while traditional engineering instruction is usually oriented toward intuitive learning, emphasizing theory and mathematical modelling. 87% of the students were visual learners, but most of engineering instruction is overwhelmingly verbal, emphasizing written explanations and mathematical formulations of physical phenomena. 61% of the students were active, while most engineering courses other than laboratories rely on lectures as the principal method for transmitting information. 55% of the students classified themselves as sequential learners and as traditional engineering education is heavily sequential, relevantly there is no mismatch between students' learning style and instructors' teaching style in this case. 34% of students were global learners. According to Richard Felder (2005) global learners are multidisciplinary thinkers with broad vision. Unfortunately, traditional engineering education is sequential and does little to provide students with global learning style to meet their needs.

As it could be seen from the results of the analysis, in engineering education there is a great mismatch between students' learning styles and instructors' teaching methods. Thus it is of high importance for engineering educators to make instruction more effective to abolish these mismatches, and taking account of them.

At Estonian Centre for Engineering Pedagogy, students attending the course for engineering educators are taught how in their future profession as engineering educators it is possible to help their students to learn more effectively. Accordingly to Felder's methodology (Felder, 2009) *active learners* should try to study in a group in which the members take turns explaining different topics to each other. They will always retain information better if they could find ways to do something with it. *Reflective learners* in turn should not simply read or memorize the material, but stop periodically, review what they have read and think of possible questions or applications. Reflective learners might find it helpful to write short summaries of readings or class notes in their own words. *Sensing learners* remember and understand information best if they can see how it connects to the real world – they should ask their instructor for specific examples of concepts and procedures, and find out how the concepts apply in practice. *Intuitive learners* should ask their instructor for interpretations or theories that link the facts, or try to find the connections themselves. *Visual learners should* try to find diagrams, sketches, schematics, photographs, flow charts, or any other visual representation of the course material that is predominantly verbal, prepare a concept map by listing key points, and colour-code notes. *Sequential learners* should outline the lecture material in logical order. *Global learners* need the big picture of a subject – they should skim through the entire chapter to get an overview and thus study more effectively.

Although the diverse styles with which students learn are numerous, the inclusion of a relatively small number of techniques as an instructor's teaching tools should be sufficient to meet the needs of most or all of the students in any engineering class. The techniques and suggestions presented below should serve this purpose in any case.

The following recommended teaching techniques by Richard Felder (1988) suitable for engineering education to address all learning styles serve as the basis of instruction at Estonian Centre for Engineering Pedagogy at Tallinn University of Technology to future engineering educators:

1. Motivate learning. As much as possible, relate the material being presented to what has come before and what will to come in the same course, to material in other courses, and particularly to the students' personal experience *(inductive/global).*
2. Provide a balance of concrete information (facts, data, real or hypothetical experiments and their results) *(sensing)* and abstract concepts (principles, theories, mathematical models) *(intuitive).*

3. Balance material that emphasizes practical problem-solving methods *(sensing/active)* with material that emphasizes fundamental understanding *(intuitive/reflective).*
4. Provide explicit illustrations of intuitive patterns (logical inference, pattern recognition, generalization) and sensing patterns (observation of surroundings, empirical experimentation, attention to detail), and encourage all students to exercise both patterns *(sensing/intuitive).*
5. Follow the scientific method in presenting theoretical material. Provide concrete examples of the phenomena the theory describes or predicts *(sensing/ inductive);* then develop the theory or formulate the mod *(intuitive/inductive/ sequential);* show how the theory or mod can be validated and deduce its consequences *(deductive/sequential);* and present applications *(sensing/deductive/sequential).*
6. Use pictures, schematics, graphs, and simple sketches liberally before, during, and after the presentation of verbal material *(sensing/visual).* Show films *(sensing/visual.)* Provide demonstrations *(sensing/visual),* hands-on, if possible *(active).*
7. Use computer-assisted instruction – sensors respond very well to it *(sensing/active).*
8. Do not fill every minute of class time lecturing and writing on the board. Provide intervals – however brief – for students to think about what they have been told *(reflective).*
9. Provide opportunities for students to do something active besides transcribing notes. Small-group activities that take no more than five minutes are extremely effective for this purpose *(active).*
10. Assign some drill exercises to provide practice in the basic methods being taught *(sensing/active/sequential)* but do not overdo them *(intuitive/reflective/ global).* Also provide some open-ended problems, questions and exercises that call for analysis and synthesis *(intuitive/reflective/global).*
11. Give students the option of cooperating on homework assignments to the greatest possible extent *(active).* Active learners generally learn best when they interact with others; if they are denied the opportunity to do so they are being deprived of their most effective learning tool.
12. Applaud creative solutions, even incorrect ones *(intuitive/global).*
13. Talk to students about learning styles, both in advising and in classes. Students are reassured to find their academic difficulties may not all be due to personal inadequacies. Explaining to struggling sensors or active or global learners how they learn most efficiently may be an important step in helping them reshape their learning experiences so that they can be successful (*all types).*

The idea is not to use all the above described techniques in every class but to choose several that look feasible and try them, keeping the ones that work, dropping unsuitable, and trying some more in the next course. In this way a teaching style that is both effective for all students and comfortable for engineering educators will effect positively on the quality of engineering students' learning.

Future engineering educators at Estonian Centre for Engineering Pedagogy must take account of presented teaching techniques suitable for all learning styles. During their studies in the subject of Engineering Pedagogy Science in Theory and Practice they prepare their teaching material in chosen engineering speciality accordingly and present it relevantly. The video record of their presentation is later analysed and discussed in the seminars.

Teaching Methods Addressing Students' Different Learning Styles

The curriculum for engineering educators at Estonian Centre for Engineering Pedagogy makes scientifically-founded and practice-oriented teacher training possible, building a deeper understanding associated with teaching engineering students.

Most students cannot stay focused throughout a lecture. After about 10 minutes their attention begins to drift, first for brief moments and then for longer intervals, and by the end of the lecture they are receiving very little and retaining less. A classroom research study has showed that immediately after a lecture students recalled 70% of the information presented in the first ten minutes and only 20% of that from the last ten minutes (McKeachie, 1999). Students' attention can be maintained throughout a class session by giving them periodically something to do.

Once a teacher incorporates students' active breaks into the lecture, an interactive lecture is given. There is no sense to stop a lecture and wait for students' questions. More effective in engineering education is to involve students actively, thus finding out questions and problems they could not answer themselves and only then answer these questions. The wide array of effective active methods in lecture should wipe off the notion that good teachers are born and not made.

At Estonian Centre for Engineering Pedagogy several controlled and tested interactive methods, suitable for engineering education are taught to future engineering educators. The students practice holding interactive lectures in seminars. The following most frequently used interactive teaching methods are taught during the study programme:

1. Pair and compare – student pair off with their neighbour and compare lecture notes filling in what they have missed, thus reviewing and processing reflectively the lecture content. Time: 2-3 minutes;
2. Pair, compare and ask – additionally to the previous teaching method, students jot down questions on the lecture content, thus the material is reviewed and analysed. Teacher answers the questions that students cannot answer themselves. Time: 3 minutes, plus time to answer students' questions;
3. Periodic free-recall, with pare and compare option – students put away their lecture notes and write down the most important points of the lecture and questions they have, thus reviewing and processing reflectively the lecture content. Students may work individually or in pairs and answer each other's questions. Time 2-3 minutes, plus time for teacher to answer students' questions;
4. Listen, recall and ask, then pair, compare and answer – students only listen to mini-lecture with no note-writing, then open notebooks and write down all major points they can recall and questions they have. They pair off and compare lecture notes and answer each-other's questions. This activity makes students to review and mentally process your lecture content. Time 3-4 minutes for note-writing, 2-4 minutes for pair fill-ins and question answering, plus time for teacher to answer remaining questions;
5. Solve a problem – students solve a problem based on the lecture content, it makes students to apply the lecture content, informing the teacher how they have understood. Time: 3 minutes for solving, 1-3 minutes to answer questions;
6. Pair and discuss - student pair off and discuss an open ended question, in order to apply, analyse or evaluate the lecture material or synthesise it with the course material. Time: 3-10 minutes, plus 5 -10 minutes for discussion;
7. Think-pair-share – teacher gives students a question or a problem and asks them think quietly, then to discuss with their neighbour and finally share with the class;
8. Students' teams achievement divisions – after a lecture students' teams receive a worksheet to discuss, complete and give oral presentation on results to others;
9. Send a problem – each group of students write a question or a problem on a flashcard and writes a right answer or a solution on the back. The card is passed to other groups which formulate their own answers and check them against that written on the back side, and write their alternative answers if necessary. At the end the original senders discuss alternative answers;
10. The one-minute paper – students summarize the most important or useful points they learned from the lecture and questions that remained. It helps students think, absorb, digest, extrapolate and internalise new material moving it to long-term memory;
11. Muddiest point – students give a quick response to a question: 'What was not clear or

confusing point in the lecture or topic?' They must identify and formulate what they did not understand. This method requires some higher-order thinking skills, ability to concentrate and pay attention;

12. One-sentence summary – students summarise concisely, completely and creatively a large amount of information of the lecture or topic, thus developing abilities to synthesise, summarise and integrate ideas and information;
13. Directed paraphrasing – develop students' ability to translate highly specialised information into everyday language paraphrasing a lesson compactly in their own words;
14. Application cards – after students have heard or read about an important principle, theory etc index cards are handed out to write down at least one possible real-world application for what has been learned. The method develops ability to think creatively, to apply principles to a new problem and situation, to draw interferences from observation.

The curriculum for engineering educators concentrates on interactive lectures and inductive teaching methods. Different active methods, suitable for teaching technological subjects, are taught in interactive lectures in the teaching process of the study programme, mainly in the subject of the *Engineering Pedagogy Science in Theory and Practice*. These methods motivate students to learn more effectively, providing teaching techniques which address all learning styles.

Inductive teaching methods suitable for teaching engineering are also taught in the teaching process of the study programme for engineering educators at Estonian Centre for Engineering Pedagogy: mainly project-based and problem-based learning, and "just-in-time" teaching.

In *problem-based learning* students are confronted with an open-ended, real-world problem and work in teams to identify learning needs and develop a viable solution, with instructors acting as facilitators rather than primary sources of information. A well-designed problem guides students to use course content and methods, illustrates fundamental principles, concepts, and induces the students to infer those things for themselves instead of getting them directly from the instructor; thus engaging the students in the types of reflection and activities that lead to higher-order learning. Problem-based learning is not an easy teaching method to implement. It requires considerable subject expertise and flexibility on the part of instructors, who may be forced out of their areas of expertise. Problem-based learning is used in the subject *Product Development and Innovation* in the described study programme for engineering educators.

Project-based learning begins with an assignment to carry out one or more tasks that lead to the production of the final product – a design, a model, a device or a computer simulation and is very suitable for engineering education. The culmination of the project is normally a written report summarizing the procedure used to produce the product and presenting the outcome.

De Graaff and Kolmos (de Graaff & Kolmos, 2003) define three types of projects in engineering education that differ in the degree of student autonomy:

1. *Task project:* student teams work on projects that have been defined by the instructor, using largely instructor-prescribed methods. This type of project provides minimal student motivation and skill development, and is part of traditional instruction in most engineering curricula.
2. *Discipline project:* the instructor defines the subject area of the projects and specifies in general terms the approaches to be used (which normally involve methods common in the discipline of the subject area), but the students identify the specific project and design the particular approach they will take to complete it.
3. *Problem project:* the students have nearly complete autonomy to choose their project and their approach to it.

De Graaff and Kolmos (de Graaff & Kolmos, 2003) note that a common difficulty faced by engineering students in a project-based environment is transferring methods and skills acquired in one project to another project in a different subject or discipline. Engineering educators should include such transference in their course objectives and should guide students to see connections between their current project and what they have learned previously, gradually withdrawing this support as the students become more adept at seeing the connections themselves. Engineering educators should also prepare students to fill in gaps in content knowledge when a need arises, taking into account the fact that such gaps may be more likely to arise in project-based learning than in conventional lecture-based instruction.

Project-based learning is used in *Elective Engineering Speciality Subjects* in the described study programme.

Just-in-time teaching combines Web-based technology with active learning methods in the classroom. Students individually complete Web-based assignments before class in which they answer questions, the instructor reads through their answers before class and adjusts the lessons accordingly ("just in time"). The use of questions to drive learning makes the method inductive. It can be combined with almost any in-class active learning approach. The preliminary Web-based exercises normally require the student to preview the textbook material. The exercises are conceptual in nature and are designed to help students confront misconceptions they may have about the course material. They serve the functions of encouraging students to prepare for class regularly, helping teachers to identify students' difficulties in time to adjust their lesson plans, and setting the stage for active engagement in the classroom. Just-in-time teaching classes are a combination of *interactive lectures*, in which the instructor does a fair amount of mini-lecturing between activities and laboratories. In the lectures, the instructor might begin by summarizing student responses to the preparatory exercises and then discussing common errors. The collaborative recitations are likely to begin with a review of the homework, and then teams of students work on new problems (Prince& Felder, 2006). Just-in-time teaching is used in the subject *Media (Teaching Technology) and E-Learning* in the described study programme for engineering educators.

Discussion

Engineering educators should gain greater confidence through the use of extended range of contemporary teaching tools by obtaining specifics of the art of teaching. Teaching methods fostering active and long-term engagement with learning tasks emphasizing conceptual understanding are used in the study programme for engineering educators at Estonian Centre for Engineering Pedagogy.

According to Entwistle (1988) students may be inclined to approach their courses in one of three ways. Those with a *reproducing orientation* tend to take a *surface approach* to learning, relying on rote memorization and mechanical formula substitution and making little or no effort to understand the material being taught. Those with a *meaning orientation* tend to adopt a *deep approach*, probing and questioning and exploring the limits of applicability of new material. Those with an *achieving orientation* tend to use a *strategic approach*, doing whatever is necessary to get the highest grade they can, taking a surface approach if that suffices and a deep approach only when necessary. A goal of instruction at Estonian Centre for Engineering Pedagogy is to induce students to adopt a deep approach to subjects that are important for their professional or personal development.

Engineering is traditionally taught deductively. The instructor introduces a topic by lecturing on general principles, then uses the principles to derive mathematical models, shows illustrative applications of the models, gives students practice in similar derivations and applications in homework, and finally tests their ability to do the same sorts of things on exams.

A preferable alternative is *inductive teaching and learning,* as used at Estonian Centre for Engineering Pedagogy. Instead of beginning with general principles and eventually getting to applications, engineering educator begins with specifics – a set of observations or experimental data to interpret, or a complex real-world problem to solve. As the students attempt to analyze the data or scenario or solve the problem, they generate a need for facts, rules, procedures, and guiding principles, at which point they are either presented with the needed information or helped to discover it for themselves (Prince& Felder, 2006).

Before teaching a topic or series of lessons using any inductive method, engineering educators should write *learning objectives* that define what the student should be able to do (explain, calculate, derive, design, model, critique) when the instruction has been concluded. If instructional objectives are at a low cognitive level, requiring almost exclusively rote memorization of facts or mechanical substitution into formulas, there is no reason to use an inductive method. The objectives should guide the choice of focus problems, learning activities, and assessment methods.

Induction is supported by widely accepted educational theories such as cognitive and social constructivism, by brain research, and by empirical studies of teaching and learning. Inductive methods promote students' adoption of a deep (meaning-oriented) approach to learning, as opposed to a surface (memorization-intensive) approach. Inductive methods also promote intellectual development, challenging the dualistic type of thinking that characterizes many entering college students (which holds that all knowledge is certain, professors have it, and the task of students is to absorb and repeat it) and helping the students acquire the critical thinking and self-directed learning skills that characterize expert scientists and engineers.

McKeachie (2006), Bligh (2000) and Nilson (2003) cite numerous studies indicating that the lecture is as effective as any other method in conveying factual knowledge. But on other criteria: attitude change, development of thinking and problem solving skills, transfer of knowledge to new situations, student satisfaction with the course, motivation for further learning and post-course retention of knowledge – the classical lecture falls short of more student active methods such as discussion. Actually the interactive lecture can be highly motivational, but its success depends on the lecturer in engineering education. Interactive lectures are used for presenting general background information – the main ideas, thus providing systematic basic knowledge, followed by the constructivist approach focusing on particular applications and problems being centred in the study programme for engineering educators.

At times an engineering educator may need to have students memorise information or master well-defined performance skills explicit teaching is used in the described study programme for engineering educators. It involves direct instruction methods (interactive lecture, practice, tutorials, handouts, assigned questions etc) and has high levels of student time on task. Goals and outcomes are made clear to students and sufficient time for instruction and extensive enough content coverage should occur. Careful monitoring of progress and appropriate pacing is carried out, and didactic questioning and feedback are used. The major features of explicit instruction are teaching in small steps, providing guidance during initial practice, providing practice after each step, and thus ensuring a high level of success. The explicit instruction should not be rigid and edifies students to observe, activate prior knowledge, construct meaning, monitor their understanding, organize and relate ideas, summarise and extend meaning. When possible, interactive approaches are used. At Estonian Centre for Engineering Pedagogy interactive lectures are of high popularity among students.

According to Prince and Felder (Prince& Felder, 2006) inductive teaching and learning is an umbrella term that encompasses a range of instructional methods, including problem-based learning, project-based learning and just-in-time teaching. They are all *learner centred* meaning that they impose more responsibility on students for their own learning than the traditional lecture-based deductive approach does. They can all be characterized as *constructivist* methods, building on the widely accepted principle that students construct their own versions of reality rather than simply absorbing versions presented by their teachers. Students are active and construct knowledge linking new information to previous knowledge.

Through inductive teaching at Estonian Centre for Engineering Pedagogy students are taught the procedures and processes of thinking and to recognise, define and solve open-ended problems which can be learned by practicing. Thus students assume more responsibility and are better motivated, becoming successful lifelong learners and better practitioners in their future teaching profession. Inductive teaching encourages students to analyse, critique, judge, compare, contrast, evaluate, assess, create, predict, apply, use, implement and gain professional perfection.

Constructivism is currently popular, cognitive view of learning is thus replacing behaviourist view – repetitive practice by the student until the knowledge and skills are mastered through direct instruction. Still direct instruction and constructivism are not necessarily opposites. Students can construct personal knowledge or meaning also through direct instruction at interactive lectures, where systematic knowledge is acquired.

Conclusions

Students have different levels of motivation, different attitudes about teaching and learning, and different responses to specific classroom environments and instructional practices. The more thoroughly instructors understand the differences, the better chance they have of meeting the diverse learning needs of all of their students.

The point of taking account of different learning styles in teaching engineering is not to determine each student's preferred instructional approach and teach exclusively in that manner. It is rather to "teach around the cycle," making sure that every style is addressed to some extent in the instruction. If this is done, all students will be taught in a manner that addresses their preferences part of the time, keeping them from becoming so uncomfortable that they cannot learn, and requires them to function in their less preferred modes part of the time, helping them to develop skills in those modes. At Estonian Centre for Engineering Pedagogy Felder-Silverman learning and teaching style model for engineering education is used as the basis for the instructional design.

Active learning exercises in interactive lectures address a variety of objectives: recalling prior material, responding to questions, problem solving, explaining written material, analytical, critical, and creative thinking, generating questions and summarizing.

Engineering courses are traditionally taught deductively. The instructor first teaches students relevant theory and mathematical models, then moves on to exercises, and eventually gets to real-world applications. Often the only motivation students have to learn the material, beyond grades, is the vague promise that it will be important later in the curriculum or in their careers. A better way to motivate students is inductive teaching, in which the instructor begins by presenting students with a specific challenge, such as experimental data to interpret, or a complex real-world problem to solve. Students grappling with these challenges quickly recognize the need for facts, skills, and conceptual understanding, at which point the teacher provides instruction or helps students learn on their own.

Quality of engineering education crucially depends on the quality of teaching. In order to improve the quality of engineering education, the foremost mission should be the improvement of the quality of education of engineering educators. Without improving the education of educators we cannot bring about any positive changes in the overall educational system. Engineering educators need a fundamental academic engineering education, professional experience and a comprehensive teaching training.

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