

Challenges of teaching and learning in first-year engineering studies – teachers' observations

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INTRODUCTION

Teachers and the teaching organisation are central actors in the instructional process. Their role is to mediate students' studying and learning process. Taken the teachers' focal role in the process we need to study the teachers and teaching organisations with the same intensity than the other aspects of the instructional process to be able to build a diverse and holistic understanding of factors relevant for developing the courses and curriculum further. However, the study [1] highlights that in the recent engineering education literature teachers' viewpoint to the instructional process is less studied.

The need for turning the research focus on teachers has been emphasized in subject matter education research literature. For instance, Fincher [2] states: "*[C]hanges in computing education must require change in the specific practices of CS educators. Hence if CS Ed [computer science education] researchers are to impact student learning we, as researchers, must investigate the practices of CS educators.*" This notion, which applies to other fields beyond computer science education as well, is also corroborated with the research results in the field of psychology and higher education. The variety of higher education studies has shed further light to how the way teachers think affects the teaching and studying. For instance, Bruce and Gerber [3] took a look at teachers' perceptions of what learning is about and how those perceptions are related to how teachers think learning is achieved. The results of Prosser & Trigwell's study [4] suggest teachers' perceptions are further related to teaching orientation, i.e., whether teachers' have teacher-centric or learning-centric orientation towards teaching [5]. Further, teachers' orientation towards teaching has an effect on whether students adopt the surface or deep approach to learning [6]. Finally, students' approach to learning has been shown to be related to the quality of the learning outcomes [7].

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However, even though the previous studies have highlighted many aspects of the way teachers think and what kinds of effects different ways of thinking may have for teaching and studying processes, the results of other studies [8] also emphasize that the discipline and the teaching context affect teaching and learning orientations. Therefore, concluding from what we know about teachers' role in teaching and learning, there is clearly a need for studies that take a look at subject matter teachers from different fields.

In addition to the relation between how teachers think and students' learning outcomes teachers' perceptions and actions may also greatly affect student retention. Teachers' role in students' social integration and institutional commitment has been recognized already decades [9]. The teachers' role in students' commitment to their studies has also been recognised in recent studies. The study of freshly graduated students in Finland highlights that especially students' first year experiences have a major effect on students' studies as it affect the motivation and commitment as a whole [10, 11]. It has been shown that success in the first year predicts pretty well success also in later study years [12]. The first year being so important we decided to focus our study on that and bring teachers who work closely with the students under inspection.

In this on-going research we aim at highlighting some aspects of how teachers experience and perceive teaching and learning processes in STEM related topics in higher education. In this paper we start by concentrating in the challenging aspects of teaching. Since we know how important the first year experiences are for students we decided to further delimit our topic to challenges teachers face when teaching first year students. Thus, the research question we aim to answer is: *What is challenging in teaching first year students at the university?* We have especially concentrated on subject independent challenges in order to be able to underline questions relevant to a larger audience of first year teachers.

1 METHODOLOGY

We conducted interviews with 15 university teachers from two Finnish universities in order to learn about teachers' perceptions and experiences of teaching first year students. We decided to collect data using semi-structured interviews because we wanted teachers' to have an opportunity to tell about their experiences with their own words [13]. In addition, interviews made it possible to ask for follow up questions and be able to clarify any unclear statements.

Nine of the teachers were teaching computer science courses and six were teaching chemical engineering courses. In order to collect data that would represent a large variation of perceptions we selected the interviewees so that there was a lot of variation in teaching experience and current job title (whether the emphasis of current job was on teaching, research and/or administration). However, all interviewees' job included teaching at least some classes.

Interviews were conducted in 2013 and 2014 and they took 10 - 70 minutes depending on how much teachers wanted to elaborate on their experiences. The interviews were tape recorded and the notes were made during the interviews. Relevant parts of the interviews were also transcribed into text. The interview plan included questions concerning teachers' perceptions of some of the focal concepts relating to the field and teachers' perceptions of *what is challenging about teaching first year students*. In this study we focus on analysing the answers to the latter question.

The data was analysed using inductive content analysis method [14]. The researchers read the interview transcripts and notes through several times and made marks on the passages where teachers talked about specific challenges they have encountered in teaching first year students. The main content of these passages was then summarised and organised into categories. The authors of this paper made the categorisation together by discussing about the focal meaning of the passage and

organising and reorganising the data until clear structure was found. The researcher triangulation [15] was an essential measure we took to enhance the quality of our results.

2 RESULTS

Altogether we interviewed 15 people. 8 of our interviewees were male and 7 were females. Interviewees' teaching experiences varied from 1.5 years to 30 years, many of them having taught 10-15 years at the university. The interviewees' work titles varied from university teachers to senior researcher and professors. In the following sections we discuss the challenges the teachers brought up during the interviews.

The teachers' perceptions on what is challenging about teaching first year students can be divided into six large categories. Each category highlights specific aspect of teaching or the reason why teachers find it sometimes challenging to teach first year students (Figure 1).

1) Teachers' (lack of) understanding of how students think

One of the most often reported challenge was the difficulty in understanding how students think about some specific topic or concept. Some teachers told that since it has been so long since they first learned about the topic themselves it is difficult to remember anymore how does it feel like not having the knowledge on the topic. Or the challenge may lay in that it is simply difficult to remember how one thinks before learning some seminal concept or topic. This adds to the challenge of trying to understand how students perceive and see the topic. Further, this makes it sometimes difficult for the teachers to find appropriate level to discuss about the topic.

"For me it is challenging because I don't have an idea how a person who cannot program thinks. It is not so much about the fact that it has been a long time since I learned to program myself but that I learned to program very fast. It happened very fast, during couple of weeks. My conceptual understanding changed in a way that now it is impossible for me to reflect on how I understood the topic before I knew how to program. I think it is a problem that I cannot understand how a person who cannot program or is learning to program thinks, what happens inside his head."

2) Students' skills and knowledge

This category can be divided into several subcategories each highlighting different aspect of students' skills and knowledge. One of the most often mentioned challenge was *big differences in incoming students' knowledge and skill levels*. First year students come to the university with varying background. Some have extensive experience on the field (either through hobbies or work experience) while others have very limited experiences and knowledge on the topic. Prior experience in the field may also sometimes result in students having strong, but limited, perceptions what the field is like or what are good methods of working on a task. This poses a challenge for teachers who try to organise courses that would be meaningful and interesting for all students.

Another challenging factor relates to *students inability to apply learned skills and transfer them to other contexts*. For instance, transferring math skills into other fields is challenging for students. "*Students can't apply mathematics they have learned into physical chemistry problems*". In addition, the same phenomenon happens also when students are asked to apply newly learned theoretical knowledge into practice. "*When asked at lectures it seems that students understand but when it comes time to do labs and home assignments and exams that they don't*".

3) Limited resources

The issues in this category relate to limited resources and high student-teacher ratio. Many first year classes have several dozens or sometimes several hundred students. This poses challenges to the teacher. For instance, how to activate large student groups in lecture halls in a meaningful way. One interviewee expresses his idea as follows *"with 50 students it possible to get discussion but when there is more the 100 students it becomes more difficult"* In addition, how to build personal contacts with hundreds of students is another challenge. Teachers recognise that students notice and value if teachers try for example to learn their names.

Limitations in physical learning environment also pose challenges especially for chemistry teachers. *"How to use the limited laboratory resources more effectively? It would be important to be able to work in labs individually, not only in groups"*.

4) How to teach "generic" skills

Many interviewees highlighted that first year students often lack some generic skills, such as, problem solving, critical thinking, and library skills needed in higher education level studies. Even though these are somewhat more generic skills compared with specific field related skills there is still need to learn e.g., problem solving in a context of own study field.

"... to get people to learn how to solve problems ... when you should think for yourself and not just look directly from a model. That seems to be difficult."

Teaching study skills was mentioned by many teachers. Especially, how to make students to realise that it is vital to attend classes and study also outside classes in order to learn something. *"Students need to work hard for their learning, also outside lectures and labs"*. If students do not attend the obligatory classes and exercise groups teachers find their possibility to help them is very limited. *"Lectures and tutorials are not obligatory - how can you affect students' learning if you never see them? The active ones do succeed"*

Teaching perhaps a bit more specific skills such as how to create viable mental models and how to help students to perceive larger entities was also regarded challenging by both computing and chemistry teachers.

5) Motivation & professional identity

Expectedly motivation rose to be an issue in many of the answers. Some teachers found it challenging to motivate students to new area. Studied issues at the first year might seem boring and useless since the students can't see the connections to themes that they will learn later. One teacher posed his argument as a question *"How to make the topic fun and useful?"*. The idea of helping students process of developing professional identity was also elaborated in the answers. Teachers found it important that students would begin to recognize themselves as experts from the very beginning of their studies.

6) Field related issues

The fact that the field itself is evolving rapidly was seen challenging especially by computer science teachers. Firstly teachers have to make sure their own skills and knowledge is up to data, and secondly teachers should be able to predict what kind of skills students need in four to five years when they graduate. For example, which programming languages students should learn. Fast evolving field may provide exciting new opportunities for students but it also poses a great challenge for them. One of the teachers described the students' situations as *"they have to jump on a moving train"*.

The field of Chemical engineering was found not to be familiar with the freshmen at Aalto School of Chemical Technology because students have studied chemistry at high school but engineering issues don't belong to the syllabus at high school.

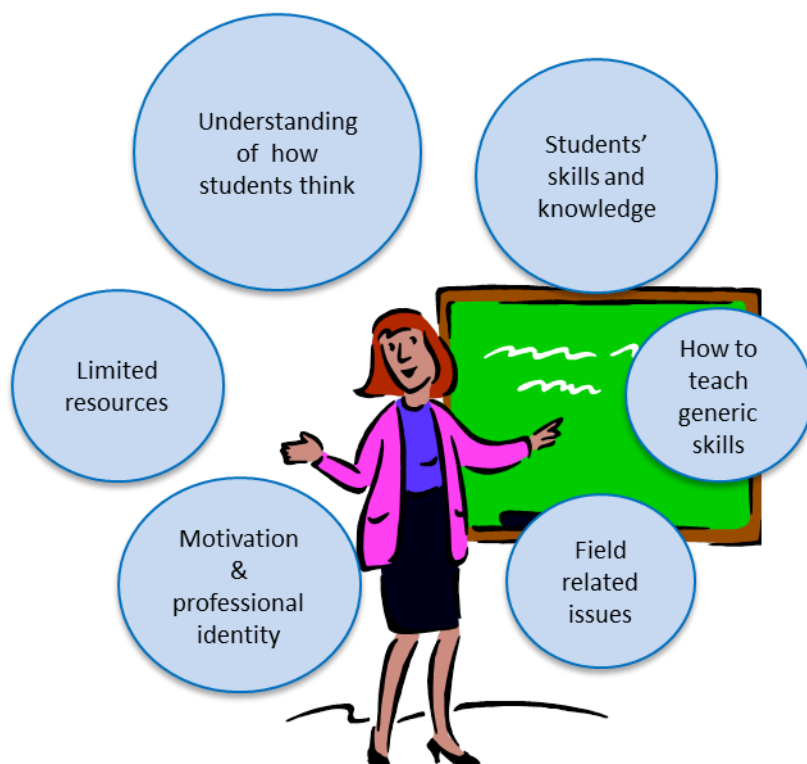


Fig. 1. Categories that emerged from teachers' answers to the question "what is challenging about teaching first year students". The size of the circle reflects how many interviewees mentioned the topic.

3 DISCUSSION AND CONCLUSIONS

The results highlight several challenging aspects STEM teachers face when teaching first year students. Some of the challenges, such as, big differences in students' skills and knowledge levels may become less problematic in later years when students have studied the same study modules and thus the teacher can also expect that students have acquired certain skills and knowledge. On the other hand, some of the other challenges may persist beyond first year. For instance, specific field related issues or coping with limited resources are potentially the kind of challenges that also second and third year teachers have to deal with. Further studies are needed to shed light into how the emphasis of what is challenging for teachers possibly changes depending on which level courses they are teaching.

This study indicates that there are certain general challenges in teaching first year students regardless of the field of studies. Interestingly the age or the teaching experience did not affect noticeable to teachers challenges. Motivating students and developing ability to study in academia were raised by both young and already more experienced teachers.

The concern about adequate lab space was the concern for a couple of chemical engineering teachers. Since there is a tendency to make the students to work in groups supports their abilities to work hands on in different way than if they would work individually. From the teachers' point of view close guidance would support students' learning more effectively. Teachers may also be more familiar with individual students in lab courses and their abilities in developing group kind of laboratory assignments could be supported more efficiently.

Now that we know what is challenging for first year teachers we need next to think how we can use it. Therefore, we highlight some of the challenges and discuss actions to make them less challenging for teachers.

- Teachers' (lack of) understanding of how students think: More research on students' perceptions of central concepts of the studied field is needed. Having knowledge of the possible variation of the students' understanding and how that understanding evolves through studies would be helpful for the teacher when he/she tries to find different ways to explain the topic. This kind of studies could be done by the teacher or in collaboration with educational scientists and psychologists. In addition, pedagogical training would also provide teachers with better pedagogical content knowledge.
- Big differences in students' skills and knowledge: Pedagogical training and mentor programs might provide concrete tools to how to differentiate teaching according different student groups' needs. However, universities could also think about adding more flexibility to the curriculum so that students with extensive background could proceed faster in their studies or take more advanced courses instead of introductory course.
- Motivation & professional identity: Letting inspiring and motivating teachers who are interested in teaching to teach first year courses. Teacher's enthusiasm (or lack of it) transmits to the students and convey the importance of the topic. Enthusiastic teacher may also provide a good role model to which students can identify to and start building their professional identity. In addition, didactic choices may help to motivate students. Telling explicitly how different courses relate to each other, what learned skills are needed for, and portraying the big overview before going into teaching details may help students to see the reason to learn the topic.
- Limited resources: Pedagogical training and mentoring programs may provide some ideas how to deal with this challenge. However, in order to solve this problem organisational level interventions are needed.

At least in Finland the ministry of education gives universities ever stronger requirements to make university education more effective meaning decreased study times and minimum retention rates. We need to enhance the success of every player in their efforts and it is important to know the challenges. Teachers have an important place to detect students' difficulties and they have to be supported also by means of taking care of their abilities to make appropriate pedagogical and didactical choices.

We conclude by noting that studying teachers' point of view has added to our more holistic understanding of instructional process. These initial results have given us motivation to continue studying university teachers, their perceptions, experiences, and their professional development as teachers.

The results of this study have inspired us to think about the possible future research topics. For instance, studies interested in students' success (or failure) at course/at a study degree program would benefit from gaining knowledge of how teachers think and act (and why) and how does it affect students' actions and perceptions. It would also be interesting to see whether the results would be different if the teachers had been asked about difficulties with second or third year students. Also since teachers and students actions are guided also by the context we suggest that also teaching organisation level aspect should be studied to better understand the models supporting high quality university teaching.

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