FIRST STEPS TOWARDS BUILDING ENGINEERING PCK - NOVICE TEACHERS IN THE CONTEXT OF PROFESSIONAL DEVELOPMENT

In Denmark engineering is emerging as a way to learn about technology and science. For this reason it is timely to devise relevant in-service training for teachers. The present study addresses the challenges engineering-novice teachers face, as they learn about engineering in workshops and experiment with the method in their own teaching practice. Using an engineering-PCK framework we report and discuss data gathered from a case study of 10 teachers experimenting with engineering and survey data from a larger population. The results shows that the novice teachers in this study were focused on experimenting with their teacher role and that the most important learning issue was for the students to learn the engineering-design-process. There was also a great variation in teachers’ uptake and performance in engineering. A final general finding is that teachers use degrees freedom to control the educative space they create for their students.

Keywords: Pedagogical Content Knowledge, Teacher Professional Development, STEM education

INTRODUCTION

In Denmark technology is a mandatory part of science curricula for primary and lower secondary students. However, engineering and learning by design has traditionally neither been part of science teaching nor of science teacher education in the Danish context. This situation is beginning to change; recently a powerful STEM-report was elaborated and handed to the government, recommending a full and integrated STEM-agenda for the teaching of science until K-10 (Bohm et al., 2017). As engineering is beginning to gain momentum it has been critical to devise relevant in-service training for experienced science teachers, introducing engineering and learning by design principles and facilitating their infusion into practice. The present study addresses the following question in the context of one such teacher professional development initiative (TPD):

What are the challenges and early practices of engineering-novice teachers, as they pave their way from workshop-like knowing-about engineering to classroom relevant learning-to do engineering (Sun & Strobel, 2014)

The TPD design was inspired by the Interconnected Model of Professional Growth (Clarke & Hollingsworth, 2002). It consisted of three workshops for all participants - each of 6 hours. These workshops were used for introduction of engineering principles, reflection activities, and peer sharing/planning/discussion. In between these workshops were intermediate periods where engineering activities were enacted and reflected locally.

For the present study, our Engineering PCK-notion is largely inspired by an amalgam of (Magnusson, Krajcik, & Borko, 2002) and (Hyun Yu, Luo, Sun, & Strobel, 2012). Yu et al has constructed a “competency model” for K-6 engineering teaching, which is intended to identify an integrated set of knowledge, skills, and attitudes that will improve elementary teachers’ engineering teaching performance and engage them in reflective practice. It is easy to place these “competences” within the PCK-framework of Magnusson et al. For this reason, our present analytical framework is an operationalization of Magnusson et al’s PCK to the context of engineering.

METHOD

The work presented here is a conceived as a case study, comprising of 10 cases of individual teachers/pairs of teachers from same schools. The ten cases are selected from a larger group of participating teachers among whom a survey were conducted, this survey provides data for the results presented here.
RESULTS

There were 73 respondents, but not all did answer all questions. Teachers open descriptions of their latest engineering activities have been analyzed to identify emerging practices:

- Approx. 70% reports that they have solely used and eventually adjusted engineering challenges provided as inputs on TPD-workshops. 25% reports to have found challenges and material themselves, typically from the internet.
- Approx. 1/3 had explicit learning goals related to engineering processes/methods. Approx. 1/3 formulated learning goals of traditional science nature (specific content learning, competences like modelling or inquiring). Others would emphasize generic competences (e.g. ability to cooperate) or student motivation as prioritized learning goals for their trials.
- 26% (17/66 open responses) indicate that students learned subject matter knowledge (SMK) as a consequence of doing engineering, while 20% offered relevant SMK before students should engage with engineering. The indication here might be that many see engineering as application of learned content rather than as path to science learning.
- Two out of three teachers indicate an emphasis on adjusting openness/the degrees of freedom in engineering activities to students’ capacities.
- Few teachers explicate scaffolding efforts - most frequently teachers refer to the Engineering-Design-Process-visualization as an useful scaffolding device.
- Assessment tends to be informal: only five teachers assess explicit engineering goals and with a single exception all assessment is product-related. Only four teachers made deliberate efforts to assess SMK-related goals.

Teachers also wrote open post-responses about their challenges when trying to implement engineering. Analysis of their responses points to the following challenges as important:

- Time/shared time for planning and developing engineering teaching (23/73)
- Securing SMK-learning outcomes - integration of SMK (13/73)
- Managing engineering goals and processes (9/73)

The last two of these challenges could be expected to affect teachers’ engineering self-efficacy. In relation to the surveys teacher engineering self-efficacy was constructed by a 4-item unidimensional index. The post-index-value of 3.3 is surprisingly high, and pre-and-post measures show that scores on all items significantly increased along the TPD.

DISCUSSION AND CONCLUSIONS

Engineering at school was in our TPD conducted as a problem-driven activity with much effort put on the students independent work. This calls for a teacher role, which is supportive rather than instructive. Despite this, few address scaffolding issues in their novice engineering education practice. This can be because either it is not challenging them to do or they did not provide scaffolding efforts to their students. Our interview data indicate that our teachers limited the degrees of freedom for the students in order to control the students work and thereby work-around the need for scaffolding in more open-task student work.

A 1/3 of the teachers were in their first teaching experiment with engineering focused on teaching the students to work with the engineering-design-process. Another third were focused on the SMK. This reveals that justification of and approach to engineering in school is formed by highly personal choices of priority. Our finding that some teachers present relevant SMK for the students prior to the engineering activities, whereas others extract SMK along the activities, supports that teachers have an individual approach to engineering in school. This diversity has led Yu et al (2012) to develop an extensive framework for analysing teacher E-PCK. However, they do not provide any clue on how such an analysis should inform the implementation of engineering. We have with inspiration from Clark and Hollingsworth (2002) put focus in
peer-to-peer discussions in our workshops as a mean for teachers to negotiate meaning and priorities (Nielsen & Sillasen, 2013).

The difference in teachers’ approach and performance to engineering can very well be a result of differences in students’ prerequisites for engaging in an engineering activity. For some students, the challenge can be the SMK, for others, it can be the practical application of SMK, for others, it can be the self-management aspect in the project-work. This calls for awareness of how to assess students’ work with engineering. We find however very few teachers who report assessment initiatives. We hope to learn more about this apparent paradox from further analysis of our ten extended cases, where the rich material opens for a more detailed understanding of each case.

In general, we find a great variation in the participating teachers’ uptake and performance of engineering, this covers over teachers’ individual search for ways to implement engineering. This could indicate that it is difficult to make a TPD that generally will help engineering novice teachers to get started. We have however found some elements, that are more common that others.

The teacher generally point to the need for time to discuss and plan in collaboration with colleagues, this can seen as an acknowledgement of problematic sides of individualisation in implementing engineering. This is supported by the fact that the majority of the teachers use prefabricated rather than develop new material or adapt existing.

A final general finding is that teachers use degrees freedom to control the educative space they create for their students; however, the shape of this space is very variable. This points to the importance of addressing the options for creating a fruitful space for developing engineering skills and knowledge with students in a TPD. Here lists on teacher knowledge and other elements for implementing engineering can provide inspiration for planners of TPD. Furthermore, participants’ TPD likely will recognize elements that they find important in their context and application of engineering in school.

REFERENCES