Danish University Colleges

Science Teacher’s pedagogical content knowledge regarding engineering.

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Science Teacher’s pedagogical content knowledge regarding engineering.

Peer S. Daugbjerg, Martin Krabbe Sillasen, Lars Brian Krogh
VIA University College
Denmark
TPD as action learning in local professional learning communities

Teachers experimenting with engineering in own teaching practice

Workshop 1
2 days

Period of 2-3 months

Workshop 2
1 day

Workshop 3
1 day

Individual & collaborative enactments at local schools

NEW KNOWLEDGE
ACTIVITIES

EXPERIENCES
INQUIRIES
SUGGESTIONS

NEW KNOWLEDGE
ACTIVITIES

EXPERIENCES
INQUIRIES
SUGGESTIONS

Research questions

1. Which elements of science teachers engineering PCK (E-PCK) could be identified in the 'Engineering i skolen' project?
2. How does E-PCK develop in the context of 'Engineering i skolen' project?

Methodologically it is a mixed methods study with many case data from the participating teachers.
Teachers’ challenges, when they start implementing engineering in science

According to literature:
- Lack of knowledge about engineering (Hynes, 2012)
  - Challenges teachers’ self-efficacy due to ‘personal unpreparedness’ (Sun, 2014)
- Inclusion of science subject matter
  - Frontloading or skipping (e.g., Capobianco et al., 2014)
- Handling student degrees of freedom in engineering teaching
  - Give up teacher control (Kolodner, 2002a)
  - Requires development of new teaching approaches (Sun, 2014)
- Assessment of outcome engineering as well as science (Kolodner, 2002b)

Pedagogical Content Knowledge (Magnusson et al., 1999)

1) orientations towards science teaching,
2) knowledge and beliefs about science curriculum,
3) knowledge and beliefs about students understanding of specific science topics,
4) knowledge and beliefs about assessment in science, and
5) knowledge and beliefs about instructional strategies for teaching science.
Engineering Pedagogical Content Knowledge (Yu et al., 2012)

- Knowledge of selecting doable and manageable engineering instructional goals
- Knowledge of student common misconceptions about engineering
- Knowledge of student common engineering learning difficulties
- Knowledge of the engineering design process appropriate for students' level of understanding
- Knowledge of the engaging design activities for students
- Knowledge of examples or analogies students can relate to
- Knowledge of examples/activities appropriately challenging for students' level of competence
- Knowledge of managing students within groups working on unique engineering projects
- Knowledge of managing groups to be on track to complete a fruitful project (balance between not enough and too much guidance or direction)
- Knowledge of organizing physical space for efficient engineering teamwork
- Knowledge of assessing projects at various levels of progression
- Knowledge of both formal and informal assessment methods for assessing engineering work
- Knowledge of using assessment data to give feedback to students for improving engineering learning
- Knowledge of making connections between engineering and real world applications
- Knowledge of simpler forms of the concept at hand to relate to something students understand
- Knowledge of physical demonstrations that reveal concepts to students
- Knowledge of probing questions that elicit exploration and thought from the students
- Knowledge of using technology resources to promote engineering learning

‘Engineering i skolen’ - empirical data

- Pre- and post-surveys to teachers
  - Test phase: 35 og 37
  - Dissemination phase: 68 og 74
- Post-survey to students
  - Test phase: 680
  - Dissemination phase: 1339
- Observations, participant self-reports, action learning forms, etc. validated through followup participant interview;
  - 14 cases total (3 men, 11 women)
  - Development phase: 4
  - Test phase: 10
  - Dissemination phase: 3
## Aims and reasons

### Identification
- 1/3 of the teachers had learning aims dedicated towards the E-processes
- 1/3 of the teachers had traditional science learning aims (concepts and science competences)

### Development
- “To me it is about getting the method [engineering] included so that they [the colleagues] uses it in their daily teaching and not like: now we have to do a special teaching unit.”

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### Analytical PCK-grid

<table>
<thead>
<tr>
<th>Orientation</th>
<th>E-Structural level</th>
<th>E-Developing level</th>
<th>E-Experienced level</th>
<th>E-Expert level</th>
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- Knowledge on engineering
- Aims and reasons
- Teaching strategies
- Orientations
- Students and engineering
- Assessment of students outcome
- Contextual knowledge

Used for deductive analysis of rich teacher-cases

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**Identification**
- 1/3 of the teachers had learning aims dedicated towards the E-processes
- 1/3 of the teachers had traditional science learning aims (concepts and science competences)

**Development**
- “To me it is about getting the method [engineering] included so that they [the colleagues] uses it in their daily teaching and not like: now we have to do a special teaching unit.”

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**29-04-2019**

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**VIU University College**

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Oversætter du disse bullits til engelsk?

Forfatter; 24-04-2019
Teaching strategies

Identification
- Problem-based teaching
- Using the EDP-model
- A teacher used dedicated worksheets for students independent work to support progression in their work

Development
- Including competence thinking
- Interviewer: “The engineering degrees of freedom, what do they support?”
- Teacher: “They support the competences. You can solve an engineering challenge without being good at science subject matter. I think that talks in favour of the method because it gives the students an option to learn how you learn.”

Orientations

Identification
- General teacher self-efficacy in being able to answer questions on engineering and being able to integrate and develop it in science teaching.
- “Engineering points towards teaching that is design-based, motivating, promoting critical thinking and where students have to be creative.”

Development
- “In a way you could say it has become much much easier to teach because now I can present them [students] a model that actually fits me.”
**Orientations - development**

**Development of teacher self-efficacy**
(N=49, only respondents to as well pre as post dissemination phase survey)

- I'm sure, that I can learn the students engineering processes
  - Pre: 3.06
  - Post: 3.47

- I'm sure, that I can integrate engineering activities in my teaching
  - Pre: 3.08
  - Post: 3.24

- I'm sure, that I can answer the students questions on engineering
  - Pre: 2.82
  - Post: 3.71

- I'm sure, that I can develop engineering activities
  - Pre: 2.88
  - Post: 3.22

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**RQ1: Which elements of science teachers engineering PCK (E-PCK) could be identified in the ‘Engineering i skolen’ project?**
RQ2: How develops E-PCK in the context of ‘Engineering i skolen’ project?

- Dissemination to colleagues
- Competence implementation
- Personal acceptance
- Increasing self-efficacy towards engineering in teacher

Thank you for listening

- Comments
- Questions
## Tabel design

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VR University College