Primary School Teachers' Development of Subject-Specific Knowledge in Technology during a Design Based Research Project

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Abstract
In this study we examine the development of teachers' subject-specific knowledge in technology during a design based research project. In the project a researcher collaborated with two primary school teachers in exploring their students' learning of technology. Throughout the whole project, the teacher-researcher group worked in an iterative and systematic way to explore the students' learning. The data draws from the groups' meetings during the whole project. In order to study the potential learning that was taking place among the teacher team during the course of the teaching project, Practical epistemology analysis (PEA) was used. During the project the teachers' expanding knowledge was based on needs of relations between their understanding of the object of learning (i.e. the capability that the students should develop) and their previous teaching experiences, technical terms and real life examples. An important factor explaining the development of the teachers' knowledge base was the discussion in the group focusing on different aspects, starting with formulating an object of learning, constructing the pre-test, identifying critical aspects and planning and revising lessons. Our study shows that it is possible for primary school teachers to significantly increase their knowledge base in technology and technology education through design-based teaching.

Introduction

The introduction of technology education in primary school has meant that yet another subject area has been added to the already long list of subjects to be taught by class teachers at these levels. Several studies show that primary school teachers experience difficulties when teaching technology due to their limited subject matter knowledge and pedagogical knowledge related to technology (Jones & Moreland 2004; Stein et al 2007). But also that subject specific training can increase teachers' confidence in teaching technology (Rohaan et al 2012) and enhance students' learning (Jones & Moreland 2004). In this paper we present a study aiming to investigate how primary school teachers who participated in a design based research project extended their knowledge in technology and technology education during the project.

Background

The study was conducted as a Learning study, which is a type of design based research inspired by the Japanese Lesson study. In a Learning study, a group of teachers, in collaboration with a researcher, together explore the most powerful way of teaching a specific object of learning. Based on phenomenographic analysis and a theory of learning, variation theory, they conduct a pre-test, plan a lesson, draw on the student's experience of the object of learning by analyzing the lesson and a post-test, refine the lesson and repeat

the cycle one or several times. During this process, the participants learn from each other and gain a deeper understanding of the object of learning in terms of what critical aspects are important to open up for variation (Marton & Ling 2007).

The participants of the study were two primary school teachers, Catherine and Julia (pseudonyms), their pupils and a researcher. The study included two classes with a total of 49 pupils in preschool class and in school year 1 (pupils aged 6–7 years). Both teachers had 7 years' experience of teaching in primary school. Catherine had former training in technology education and a few years' experience of technology teaching, while Julia had neither any training in technology education nor any former experience of teaching the subject. The study was carried out during one semester.

A Learning study takes its starting point from an object of learning that is chosen by the teachers and researcher together on the basis that it is central to the curriculum, and usually it is a topic that involves difficulties for the students. In this study, the capability to construct a linkage mechanism was chosen as the object of learning. The field of mechanisms is part of the core content in the new Swedish Technology syllabus from 2011 (National Agency of Education 2011), and it's also a common content in the existing technology teaching practice.

A vast range of data was collected during the Learning study. In this study we will focus on data from a total of seven meetings with the teachers and the researcher, referred to as the "teacher team". During these meetings all stages of the study were discussed, starting with the choice of object of learning. The meetings also included shared viewing and analyzing video recordings of lessons and pre- and posttests (see Table 1.). Each session was about one and a half hour long. All meetings were audio recorded and transcribed, excepting meeting 5 when the audio recorder accidently was turned off, and notes were taken directly after the meeting in order to sum up the discussion. The transcribed recordings were analyzed.

Table 1. Outline of activities performed during the Learning study.

Activity	Date	Content
Meeting 1	Sept 11	Discussing the purpose of the study and choosing the object of learning
Meeting 2	Sept 25	Discussing and analyzing the object of learning, constructing the pretest
Pre-test		
Meeting 3	Oct 9	Analyzing the pre-test and planning the lesson
Lesson and post-test		Cycle one
Meeting 4	Nov 14	Analyzing cycle one and planning cycle two
Revised lesson, post-test		Cycle two
Meeting 5	Nov 27	Analyzing cycle two and planning cycle three
Revised lesson, post-test		Cycle three
Meeting 6	Dec 4	Analyzing cycle three

Meeting 7	Dec 6	Summing up

Method

In order to study the potential learning that is taking place among the teacher team during the course of the teaching project, we have chosen to use Practical epistemology analysis (PEA) (Kelly et al 2012; Wickman 2004; Wickman & Östman 2002). This type of analysis has developed out of a need "to describe actual epistemological practice, that is, how people proceed in action to accomplish certain purposes" (Kelly et al 2012, 285). PEA studies have been performed on students while involved in solving tasks during school work, such as laboratory exercises (Wickman 2004; Wickman & Östman 2002). Learning in the PEA perspective is seen as the creation of relations in the process of accomplishing tasks, and "[l]earning thus necessitates that the participants of a discourse notice the need for new relations" (Wickman & Östman 2002, 605). The analytical tool to study the need for new relations is "gap" (Ibid.). Wickman and Östman have a broad conception of a gap, meaning the potential plurality of interpretations and misunderstandings opened up by any type of act. In their words, "[w]hen people encounter something (utterances, artifacts, natural phenomena, etc.) during talk or in action, a gap occurs" (Wickman 2004, 328). For example, say that you enter a bar, and that you approach the bar counter and say "A pint, please" to the bartender. If the bartender responds to this by pouring a pint of ale to you and if you happily accept this, a gap is said to be "closed". A relation has been created between "A pint, please" and the bartender giving you a pint of ale. In the analytical framework of PEA "a pint" is said to "stand fast", meaning that both you and the bartender take the meaning of this term in the context of a bar for granted. On the other hand, if the bartender hands you a glass of 0.473 litres of beer you may be confused, meaning the gap is not closed, but unfilled. Coming from UK a pint means 0.568 litres and you might end up in a discussion with the bartender about different measurement systems in UK and US and in this gaining knowledge in relation to both metric systems and the meaning of "a pint", thus learning through creating new relations (filling gaps in relation) to the action "A pint, please".

When gaps are not filled, this means that certain relations necessary for action are not solved. Both these types of gaps, filled or unfilled, are of interest in this study. But not all gaps that arouse during the teacher team meetings are of interest to us. Much of the talk during the meetings regarded aspects that did not concern teachers knowledge in teaching technology, such as gaps raised in relation to discussion about new meetings, permits (to film students), small talk etc. In this study we have concentrated on gaps introduced and filled in relation to technical subject matter knowledge and pedagogical content knowledge. However, our intention is not to present the entire learning taking place during the seven meetings, as that would have required a far too extensive article. Instead, we will concentrate our analysis on the main mechanisms through which the practical epistemologies of the teacher team acquired relevant knowledge during the meetings, that is, are there recurrent gaps of certain kinds that seem productive in relation to the task of teaching technology? These recurring themes in the discussion can, from the PEA point of view, be characterized as epistemological habits, as they indicate patterns of inquiry-behaviours that construct knowledge needed to solve the tasks.

Results

In this paragraph we will start by giving a short summary of the meetings, focusing on the first three meetings and illustrating the analytical tools through selected empirical examples.

After this we will present what we found to be the most important patterns in the practical epistemologies, that is the way the team managed to solve the task of constructing a relevant teaching for the students.

Starting with meeting one, the first gap of interest for us arise when the researcher states that an object of learning should be determined on the basis of their (the two teachers) past experiences, more precisely on the basis of the problems they think their students have in learning technology.

Researcher: in this first part it's important that we really have talked about what we think is difficult for the students, what they usually have difficulties with, and what kind of knowing we think this is
/../
Catherine: Hrm, but, and it's important that you do the pre-test, the hardest thing, in a way that identifies something that usually is difficult. Then it's like this, usually, usually is difficult, it feels like, you know (laughing), not quite

This gap is not filled as the teachers claim to lack previous experiences. The project could have ended here, simply concluding that the premises for a Learning study were not there. But the group continues and tries to close the gap; that is, choosing an object of learning by trying to construct other relations. One strand in their attempts to close the gap – to decide on an object of learning – is to base the object of learning on the content as specified by the national syllabus. Mechanisms, materials and electricity are areas that are picked up from the syllabus by the team. But this does not seem to be enough to close the gap, partly because the syllabus does not provide enough information about how to proceed in the actual teaching.

In exploring the possible object of learning, the teachers pursue another strand, namely their earlier experiences of teaching using ready-made teaching materials such as LEGO and NTA (a type of "teaching boxes" that include instructions and that build on Science and Technology for Children (STC), a material produced by National Science Resources Center (NSRC)). In this, relations are created between the areas pointed out in the national curriculum, examples given by the researcher and the teachers past experiences. However, some of the constructed relations are broken as they are considered to involve science and not technology (for example certain ways of working with levers). This means that relations of two kinds – both similarities and differences – are created between past experiences, concrete examples given and possible learning objects in technology. Through these new relations, one can say that the team is constructing a deeper understanding of technology education. To take one example, the teacher Julia, who lacks experience of explicit technology training and teaching, comes to the realization that some of her former teaching in fact relates to the technology subject.

Julia: I've made a lot of things with paper fasteners, that you can build [...] I've been working with technology more than I first thought, I think

Another gap that arises in relation to past teaching experiences concerns ready-made teaching materials. The team argues that that such materials are often linked to very specific lesson plans and thus not possible to fit within the framework of a Learning study that

demands openness regarding these aspects. One of the teachers tries to close this gap by suggesting that only part of the ready-made materials may be used, and in a more independent way. But the team does not to proceed in further exploring this, and this thus becomes an unfilled gap.

Another recurring theme during meetings one and two are the teachers' search for specific terms related to the object of learning. A gap between the object of learning and the specific technological terms is thus noticed. To take an example of this:

Catherine: what do you call this one? A shaft?
Researcher: lever for transferring a movement
Catherine: you have to have a pivot point for transferring a movement
Julia: lever with a pivot, or?
[---]
Julia: but we can say that then, like a jumping jack, well, what should we call this part?
Researcher: a strip, a paper strip
Catherine: and the technical is? The technical term, what is it?
Julia: the strip (inaudible) (laughing)
Researcher: yes it's a link
Catherine: a link, it sounds professional
Julia: but then this one is also a link, though of a different material

The urge to find suitable terms thus seems to increase the teachers' content knowledge.

Even though certain gaps are filled, this is sometimes just temporarily, as already indicated. During meeting three, it is clear that one of the teachers is not satisfied with how the link to real life examples worked out during the lesson. Despite several new attempts to address this lack of connection to reality, through for example showing the students a pedal bin and discussing it during lessons, the connection to reality ends up as an unfilled, but yet important, gap to the teachers.

Julia: it's important that they get an image, maybe of a seesaw or something, to connect it to reality
Catherine: yes
/../
Julia: some machines /../ a pump to get water
Catherine: they haven't seen those, and a jumping jack is such a constructed toy. Are there any railway barriers?

During meetings three and onwards, recordings of the pupils work with the tasks are analysed by the team in order to further develop the lesson plan. These recordings, together with the fact that lessons are held in between the meeting come to challenge established relations that again have to be closed, etc. In this way, the team developed deeper and deeper understanding of the technology teaching performed.

In relation to the teachers´ expanding knowledge of technology and technology education, we would like to mention three significant and recurring themes of gaps, or "epistemological habits" that have been identified in the material. These gaps regard relations between the

teams' understanding of the object of learning and teachers' previous teaching experiences, technical terms, and real life examples.

Discussion

Taking into account the participating teachers' limited experience of technology teaching, they never the less bring in many previous teaching experiences in trying to work out what the Learning study should deal with. Even though not all past experiences are considered to be relevant, many of these experiences contributed in some way or another to develop their common knowledge of technology and technology education. For example, when mechanisms are first suggested as a learning object, one of the teachers connects this to her work with levers in a ready-made teaching material. The discussion in the group deals with how levers and mechanisms are related, and how levers normally are used in primary education to illustrate science, and not technology. Another example is when the researcher shows concrete examples of mechanisms models. The teacher Julia explains that she has indeed worked with these types of constructions but never thought of it as having a technical content. In this process, it is of course important that the group of teachers have some expertise in the field so that the technological content can be recognized. In a Learning study, the researcher often plays this role, and also did so in the present study. This being said, there were several occasions in which the teachers themselves brought new important terms into the process of developing knowledge of the learning object.

We talked about these types of recurring inquiry patterns as epistemological habits as it helped the teachers gaining new knowledge. Another epistemological habit that was discerned in the meetings was that the teachers, especially one of them, again and again comes back to the question of how the teaching is or could be linked to real life examples. As we see it, this relation between the object of learning and real life technology, contributed to develop the teachers' understanding of the object of learning as well as presenting meaningful contexts for teaching. Lastly, also the urge among the teachers to acquire new technically relevant concepts was important for the task of developing the technology lessons during the Learning study.

To summarize, the teachers developed a more specialized approach to technology teaching and learning during the course of the study. An overall factor explaining this is that the team managed to continually elaborate on the technological aspects of the teaching and learning of their students, which is in line with findings by Jones & Moreland (2004). This also means that the Learning study model work for the team despite the fact that the two teachers had no training in either the Learning Study framework or in the theory used, variation theory.

This study is a limited case study with only two teachers participating in a project during one semester. Nevertheless, the results of this study indicate that teachers' knowledge of technology and technology education can be significantly developed by approaching teaching and learning in technology through a delimited object of learning in an iterative way and in collaboration with other teachers. That the team developed epistemological habits can be seen as a sign of what Rohaan et al (2012) have talked about as a positive reinforcement, that is, the team did not settle for solutions or facts but continued to be curious and question whether the teaching they had come up with was best or if it could be improved. These types of habits have been stressed as vital in the modern society where you always have to learn anew and never settle.

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