Planning science instruction: From insight to learning to pedagogical practices

Proceedings of the 9th Nordic Research Symposium on Science Education
11th-15th June 2008, Reykjavik, Iceland

Synopses: Learning to teach science

December 2008
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Development of pre-school student teachers’ content knowledge and attitudes towards science and science teaching

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Background, aims and framework
Considerable concern has been raised in Sweden about the problems faced by students in learning science and the decreasing overall interest in science (Helldén, Lindahl & Redfors, 2005). One of the reason for this situation is the way science is taught (Lindahl, 2003; EU, 2004). To bring about a radical change in young people’s interest in science education there is therefore a strong need to renew science education in schools (EU 2007).

One key to an improvement of science teaching is the establishment of a pre-school teacher education that provides becoming pre-school teachers with a sound basis of general science knowledge, enabling them to teach science with confidence (Carlsen, 1991; Harlen, 1997; Kallery & Psillos, 2001). This is of great importance as a positive contact with science at an early stage will influence the attitudes of young children towards science (Harlen, 1997). Also, an early experience of quality science education will lead to a better understanding of scientific concepts studied later in a more formal way (Eshach & Fried, 2005; Novak 2005). The importance of an early exposure to science is now also formalized in the latest Swedish curriculum for pre-schools, Lpfo 98 (Utbildningsdepartementet 1998), and elementary schools, Lpo 94 (Utbildningsdepartementet 1994). Here it is stated that also young children should be taught science. Placing a greater emphasis on science in pre-school teachers’ education is although not uncomplicated. Pre-school student teachers often have a rather estranged relationship to both science and science education (Rice & Roychoudur; 2003, Howitt, 2007). Usually they see themselves as “non-science” people and typically they have poor science knowledge. They also often have negative attitudes towards science, remembering science at school as a negative experience (Garbett, 2003; Lager-Nyqvist 2003). The main reason for them to enroll pre-school teacher programmes is the wish to work with small children, not to teach science. Teacher education for pre-school teachers including science is therefore facing a challenge, where the education need to provide a sound basis of general science content knowledge as well as enhancing student teachers confidence in teaching science. Because of the strong correlation between teachers’ scientific knowledge, their confidence in teaching and quality education, teacher educators thus have an important role of both teaching science and establishing a learning environment that improves attitudes towards science and science teaching (Carlsen, 1991; Harlen, 1997; Kallery & Psillos, 2001). Also, the teacher’s epistemological beliefs, teaching contexts, and instructional goals are reflected in the teacher’s teaching practices (Kang & Wallace, 2005). For example, an orientation towards more constructivist beliefs about learning have effects on the design and the use of different, more open and student-centred tasks, which again have effects on students’ achievement (EU, 2004).

The present study attempts to obtain at a better understanding of the development of pre-school student teachers science knowledge, attitudes towards science and science teaching during their university studies.

Methods and samples
This study contains two parts involving two different batches of students enrolled in the same programme for pre-school teachers. This programme, which is called “Science and creative art”, starts with one semester of didactics. Thereafter two semesters of science integrated with art follows. These courses contain a mixture of lectures, excursion, creative elements, group discussions and individual or group projects. After these two semesters another five semesters of didactic and subject based courses follows before the students graduate.

The first part of the study concerned the learning outcome of one of the science courses. This was studied by comparing the students’ (N=60) and lecturers’ description of the scientific content of three lectures. This was done with an underlying assumption that a well functioning interaction between the lecturer and the students plays a vital role for the development of the students’ science learning and attitudes (Rice & Roychoudhury, 2003). The lectures had the titles “Winter from a scientific perspective”, “Small animals in winter” and “Mammals in winter”. The lectures were picked so that they were held by two different science teachers. They were also chosen to cover both “concrete” information (species, adaptations) and more abstract information (physical and chemical perspectives). After each lecture each student was assigned to describe the core of the lecture in one sentence. They were also asked to describe what they had understood as the three main “messages” of each lecture. A couple of days after each lecture, group discussions were held with the same assignments. All groups thereafter handed in one description that the group had agreed on, along with the group members individual descriptions. All descriptions were then categorized according to how well they agreed with the lecturers’ description of his/her own lecture. A comparison was also made between the students’ individual descriptions and those made by the groups.

The second part of the study involves the next batch of students and is the initial phase of a longitudinal study. Here the students’ epistemological beliefs and attitudes towards science and science teaching are to be followed through their university studies. The student teachers’ attitudes towards learning and teaching science were investigated by...
a questionnaire handed out at the start of their first semester. The questions here concerned their attitudes towards learning (modified from Leavy, McSorely & Boté, 2007; Martinez, Sauleda & Huber, 2001) as well as their reasons for enrolling the program. Six month later, when the science and art courses begun, a second more extensive questionnaire was handed out. Here the questions both concerned their attitudes towards learning as well as their attitudes towards science and science teaching. Both these aspects will be followed by further questionnaires and interviews through their university studies, and possibly also during their first years as teachers.

**Results**

The results of the first part of the study showed that 60-97% (depending on lecture) of the students descriptions, were categorized as very close (almost identical) or close (details differing) to the lecturers’ own description of his/her lecture. After discussing in groups, 90% of the groups’ descriptions were categorized as very close to the lecturers’ own description. Those cases where the students did not produce a description closer to the lecturers’ after discussions always concerned abstract issues, such as how the inclination of light affects the energy input to the earth, or the surface/volume ratios effect on heat loss of a body. In those cases the group discussions even sometimes led to a deeper misunderstanding, reflected by descriptions very different from the lecturers’.

In the second part of the study, which still is going on, the first questionnaire showed that the majority of the student teachers shared views of teaching and learning as transmission of knowledge, i.e. behaviouristic views (53%). Smaller groups expressed constructivist or sociocultural views (26% and 12% respectively). In the second questionnaire a shift in views, from behaviouristic (now 37%) towards sociocultural (now 30%), was evident. Some caution must be taken when comparing the two first questionnaires however, as he first questionnaire was answered only by 37 of 65 students (57%). This low return was due to the complicated process of sorting out those students enrolled in the program from other students as they start the first semester mixed with students of other programmes. The second questionnaire however was answered by 55 of the students (85%). From the second questionnaire it was also obvious that the majority had a positive attitude to science or science teaching as long as science could be interpreted as “nature” or “outdoor-life”. If science was interpreted in the context of “chemistry” or “physics” however, the majority held less positive or even negative attitudes. In addition, very few of the student teachers had any memories of science being taught in their own pre-school years. Further, one third remembered science learning as an easy task later in school, while one third remembered it as difficult. Results from the following questionnaire held at the end of their first semester will be at hand in June.

**Conclusions and implications**

From the results one may draw the conclusion that group discussions can be a fruitful way of helping students to a better understanding of the content presented in a science course. One should however not underestimate the important role of the science teacher, especially when it comes to the abstract parts of the issues dealt with.

The shift in epistemological beliefs from behaviouristic towards sociocultural views among the students after their first semester at the program reflects the didactic content of the first semester of the programme. During this semester literature covering pros and cons of different epistemological views are discussed. If, and then how, these attitudes are changing during the first semester of science will be examined in a new questionnaire at the end of the semester.

**References**


**Case studies and video from students’ school practice used in teacher education**

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**Background and research aims**

A number of research projects in recent years have looked at ways of documenting and developing teachers’ professional knowledge. One theoretical framework is PCK (Pedagogical Content Knowledge) (Shulman, 1986, 1987). A number of studies have tried to capture the knowledge of experienced science teachers and other studies have looked at the needs of novice teachers at the start of their classroom careers (Sorensen & Andersen, 2004; Ellebaek & Evans, 2005). Articulating links between professional teacher knowledge and practice in a way that can be represented to others has proven difficult, however the method of using an interaction of CoRe (Content Representation, linked to a particular content) and PaP-eRs (Professional and Pedagogical experience Repertoire: teachers’ narrative cases) is seen as a breakthrough (Loughran, Mulhall, & Berry, 2004). The method is used to portray experienced teachers’ PCK, but is recommended to be used in science teacher preparation programs as well (Loughran et al., 2004). Along with research showing the importance of systematic use of students school practice in teacher education (Korthagen et al., 2006), this encouraged the development project described in this paper.

The research question was:

- What effects can be seen on student teachers’ approaches to teacher education (in geography) when using case studies and video from students’ school practice in combination with a systematic CoRe approach?

**The teaching project**

Aarhus Teacher Training College in Denmark has worked on a number of development projects over the past years, all aimed at improving the training of specialist science teachers. The main theme of these projects has been the integration of subject matter, pedagogic/didactics and school practice.

This development project is founded in a geography class and involves student teachers in their fourth and last year of teacher education. Three different approaches were used:

- case studies from students’ school practice in autumn 2007, described by the students as reflective narratives
- videotaped sequences from students’ school practice
- content representation (CoRe) associated to different themes, described by the students in groups.

All case studies and chosen video sequences were later used in the student teachers’ own class and the case studies were used as background and inspiration in the class work on content and didactics that followed the teaching practice.

The purpose and aims can be placed under two headings:

- a teacher education perspective; qualification and innovation in the teacher education didactics
- a ‘learning how to teach’ perspective: developing the students’ professional teacher knowledge.
Besides PCK, the theoretical framework is educating the reflective practitioner (Schön, 2001) and the use of video and case-writing in practice learning (Shulman, 2002, 2003), individually and in a community of learners (Shulman & Shulman, 2004; Shulman & Sherin, 2004).

Methods and sample

This paper reports the initial evaluation. A semi-structured group interview with all 10 students was conducted in autumn 2007 (Kvale, 1997). Interviews were to be repeated at the end of the spring term. Quotations from the first interview are used below.

Case studies from all students’ school practice grade 8 and 9 geography, and notes from three student groups, where they suggest themes to focus on in the period after teaching practice, is used as background material below.

Examples from two students’ teaching are below used in discussion of teaching issues in the complex field of climate change. These two video-sequences are transcribed and the dialogue is analysed in order to discuss what seems to happen (Fairclough’s model in Joergensen & Philips, 1999) and what meaning the students make from this teaching situation. This analysis is not a part of the paper, but examples of dialogue from these video sequences, and a CoRe connected to Climate Change, will be presented at the conference.

Results

Interviews with the students revealed their strong commitment to this kind of ‘practice learning’ approach and actually showed that they were a little surprised about the enlightenment that developed from working with both their own, and the group’s, case histories.

One student commented when talking about her experience of reading fellow students’ case studies:

When I first got the task I didn’t see it different from all the other practice papers we have been doing during the study, but I was very surprised with how engaging it was to read cases from the others...

The students identified many parallel problems in their case histories, for example, nearly all of them did, in one way or another, reflect upon how to engage and motivate school pupils (‘pupils’ is used in the paper to differentiate from teacher ‘students’). The case studies also complemented each other. By way of example one student’s case history showed how some pupils originally not interested in the Danish landscape and the ice-ages (natural climate changes), became clearly more engaged when working with man-made climate changes. Another student’s narrative tells about pupils engaging in work about the various consequences of booming industrial development in China. In contrast a third student experienced pupils who preferred the simple task of colouring a map from more discursive approaches. As one student noted:

Actually it was nearly the same kind of problems we focused on… you know these considerations on how to motivate the pupils and catch their interest... but some of it gave a quite new... a somewhat totally different view on the problems...and how to tackle the teaching……

In the field of teaching the carbon cycle and climate change one student’s reflective narrative was about how to teach the complex and highly abstract concepts in a discursive way. She asks:

What do the pupils have to know and understand about the carbon cycle and how well do they have to know it and how do you avoid a monologues teaching approach?

When examining the videotape from this student’s teaching, a sequence was chosen and used in the discussion. In this class situation the student teacher is trying to focus on the abstract parts of the carbon cycle, while the pupils respond in a concrete manner with examples about possible effects of global warming. Closer examination shows that the pupils, although clearly very interested, did not differentiate the green house effect from ozone layer dilution, they did not differentiate natural climate changes from manmade ones and they did not identify green house effect as an important issue for life on earth (they didn’t identify the problem as increased green house effect). A video-sequence from another student teaching climate-change show pupils asking a lot of question in association to an examination of melting ice in water, which do not produce an overflow, as they expected.

These important science ideas are included in the CoRe made in association to teaching Climate Changes.

The school pupils’ problems understanding these complex science ideas, in spite of focus in education and public debate, is not new. Typical misunderstandings have been broadly documented in research (Andersson & Wallin, 2000), and the student teachers had discussed such issues before, but the narrative case seems to make the students see it more clearly and in a context.
The videotaped sequences were in this way used to further illustrate issues from the cases. As one student noted:

All approaches give something important... video shows some other things... more like a close up... and we share what we see in another way..

After working with all cases in the class, the students, organised in groups, were asked to discuss (while taking notes) the question: What do we need to learn the rest of this year to be good geography teachers? The students’ proposals are inspired by the cases, the content and didactics seen together (Carbon cycle/climate changes: important science ideas and different approaches to motivate school pupils, etc.). This is mentioned because integration of subject matter and didactics is the great challenge in teacher education.

Conclusions and implications

On first evaluation this project is promising. The students seems to develop their individual reflection in and on action, as well as reflection in the community of learners represented by the geography class, and the cases are used to see content and didactics in a context, which can be seen as a step in developing PCK, not only in association to the content they teach themselves, but in association to the common knowledge base, represented by all cases. In this way the use of three different approaches (case studies as reflective narratives, video-sequences as close-ups and CoRe as a systematic view on teaching given content to a given group of pupils) is a promising method for developing teacher education didactics.

At the end of the final year of teacher training further evaluation will be undertaken to assess the value of case studies as a common knowledge base in the study, and see if the student teachers use case histories in the final exams.

Clearly the numbers of student teachers involved in this development project are small and further research is recommended with respect to the use of the case histories as part of the students’ portfolios for their final exams, etc.

Another area for future examination is investigating the possibility of using a similar approach during teacher induction programs. Research has identified that both pre-service and novice science teachers have low self-efficacy (Sørensen & Andersen, 2006; Sherman & MacDonald, 2007) and this method could be a way of working with new teachers crossing the border into practice.

References


Analysis of communication in student teacher videos during teaching practice
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Background
It could be useful for a novice science teacher to plan social interaction and teacher talk from the point of view of each particular learning situation. For example, a student teacher may not ask questions, help pupils to recognise their previous conceptions, or scaffold pupil thinking before and during the inquiry activities i.e. demonstrations. Furthermore, what is observed in the post-activity inquiry may be ignored. The student teacher may simply continue and explain what was observed and how the observation should be interpreted. There is an emphasis on studying teacher talk in the science classroom in the framework presented by Mortimer and Scott (2003). We assume that in the communicative approach, listening to the pupils’ voice will engage pupils in learning and help them to recognise their own conceptions.

Mortimer and Scott (2003) make a distinction between the authoritative and dialogic aspects of teacher talk. In the former, the focus is on scientific models and a teacher uses Socratic questioning (having one correct answer in his or her mind) and in the latter, the focus is on pupil thinking.

At the University of Helsinki, pedagogical studies consist of studies in general education, pedagogy and teaching practice. Theoretical studies within pedagogical studies are linked to school practice in several ways. At the beginning of the studies, the theoretical basis for teaching and learning of a subject is introduced and students also visit schools to observe lessons and, moreover, participate in micro teaching sessions. One important component of our teacher education programmes is that students learn to reflect on experiences during teaching practice (Husu, Toom & Pärtikainen, 2008). This reflection is regarded as a necessary condition for teachers to continue to steer their development of professional knowledge.

Pedagogical studies in physics teacher education
At the University of Helsinki, physics teacher education is organised through co-operation between the Faculty of Science and the Faculty of Behavioural Sciences (for more, see Kaivola, Kärpijoki & Saarikko, 2004). Studies are divided into two parts: the subject is studied in the Department of Physics and pedagogical studies at the Department of Applied Sciences of Education and in two teacher training schools.

Pedagogical studies consist of studies in general education, pedagogy and teaching practice. Typically, the following areas are discussed within studies in pedagogy: teaching and learning science, student interest and motivation in science, the national and local curriculum including curriculum planning, teaching methods, information and communication technology (ICT) in science education, and evaluation and research methodologies in science education research. Through these courses student teachers become familiar with psychology, sociology and philosophy of learning, history of education, multicultural aspects of education and special education. One third of the pedagogical studies consist of teaching practice (20 credits). This takes place in both university practice schools and municipal network schools. The physics student teachers are taught to plan, organise and evaluate teaching during the first course of the pedagogical studies. In addition to basic teaching methods, the ideas of the communicative approach are introduced. During the first teaching practice, the students plan teaching sessions in small co-operative groups and also teach together in a classroom (Lavonen et al., 2007).

It is a challenge to combine theoretical studies with teaching practice. Many students feel, especially at the beginning of their studies, that theory and research-based knowledge about teaching and learning a subject is something that they must study but which is not closely related to the actual work of a teacher (Hagger & McIntyre, 2000; Korthagen, 2004). Therefore, theoretical studies within the programme are linked to school practice in several ways. At the beginning of studies, the theoretical basis for teaching and learning of a subject is introduced and students also visit schools to observe lessons and participate in micro teaching sessions. Moreover, theory and practice is related by videotaping the first teaching hours during the teaching practice. These videos are also analysed by students and they should also combine both theoretical knowledge and practice.

Research question
The practical aim of this study is to develop our physics and chemistry teacher education courses. The research question is:

- How do different types of talk appear in student teacher teaching practice?
Methods and samples

Teaching sequence
We chose student teacher videos on classic physics topic from teaching practice. During the first pedagogical course the student teachers recorded on video one task. This was a demonstration (e.g. heat expansion with an iron ball and iron disc with a hole; duration 5 – 10 minutes). They then analysed it following the ideas of the communicative approach. Altogether, we had 22 student teacher videos for the analysis.

The task was used in the science teacher pedagogical studies in the year 2005 and 2006. The student teachers chose the demonstration they wanted to videotape. They used cameras from training schools. They were small digital cameras using flash memory cards and had a USB port to connect to a computer. We established a WebCT platform for the videos and student teacher analysis. A student peer was the video operator.

This paper presents the preliminary analysis of the social interaction and teacher talk in student videos. The authors watched the videos and discussed their preliminary findings; and based on these findings and classification of teacher talk (Table 1), one author analysed the videos following the ideas of deductive content analysis (e.g. Patton, 2002).

<table>
<thead>
<tr>
<th></th>
<th>Interactive</th>
<th>Non-interactive</th>
</tr>
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<tbody>
<tr>
<td>Authoritative</td>
<td>Question – answer – evaluation</td>
<td>Lecturing</td>
</tr>
<tr>
<td>Dialogic</td>
<td>Discuss – student voice</td>
<td>Reviewing student voice</td>
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Results
As expected, every student teacher used authoritative / non-interactive talk. Most of the students (18/22) used dialogic / interactive talk at least once in their videotaped teaching practice session. This type of talk was used in several ways, for example, while predicting what will happen, while explaining why it happens in a certain way, while discussing the source of error in the demonstration, and while discussing solutions for demonstrated phenomena. Only two student teachers had the sequence dialogic / interactive; authoritative / interactive; authoritative / non-interactive. The typical dialogic / interactive talk sequence appeared before and after authoritative / non-interactive talk. Student teachers seem to be happy receiving any type of response from pupils. There was a question, one or two answers, and then the student teacher lectured.

As teacher educators, almost every year we see students who have the opinion that there is no use in asking questions. We were relieved to find that every student teacher in the videotaped demonstration used in the very least authoritative / interactive questioning. Videotaped demonstrations did not represent the deep understanding concerning the importance of the previous knowledge of pupils. None of the student teachers used dialogic / non-interactive talk. As the majority of student teachers seem to ask pupils about their views during teaching, we expected that some of the student teachers would revise previous discussions.

Conclusions and implications
Student teachers asked questions; and often the questions were dialogic. However, the analysis showed that student teachers have difficulties in taking into consideration pupil views. In teacher education the importance of pupil views and building on these needs more emphasis. But the results show the difficulty of building on pupil views. Perhaps student teachers focus more on content and less on pedagogy, especially with regard to pupil preconceptions. Moreover, in teacher education, more emphasis should be put on using a larger variety of teacher talk (Ogborn, Kress, Martins, & McGillicuddy, 1996).

We found that separate video and student self-reflective analysis is technically very clumsy. In the academic year 2007-2008 we are piloting a new web-based video commenting system called Victor. In the system, a student teacher can add comments to the video, and videos can be shared with peers and mentor teachers.

In teacher education, videotaped practice has great potential for improving reflections in order to improve communication while teaching. In the near future it is possible to make videotaping routine. Reasonable video cameras are available, for example, in mobile phones; however, more usable software and guidance for improving the versatility of talk in the classroom is needed.

Acknowledgements
The use of ICT endeavours described in the paper are supported by EuSE - Effective use of ICT in Science Education project (226382-CP-1-2005-1-SK-COMENIUS-C21)
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University students’ personal ideas about school physics as a starting point for dialogic/interactive talk
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Background, aims and framework
In this study the views of aeronautical engineering students of physics lessons were investigated in a dialogic/interactive (Mortimer & Scott, 2003) talk between a student and a discussion partner in an interview situation. The background is that the current physics course had a compulsory task when students solved a context rich problem, and the discourse when students were deep in conversation during small group work with problem-solving (Enghag, Gustafsson & Jonsson, 2007; Enghag & Niedderer, 2008) was analyzed. A main finding of the study was that one student in the group often had specific personal ideas, experiences and questions driving these group talks. The personal questions made the other students interested, and decided the direction of the group work. We concluded the physics course with student interviews about physics as subject-matter. The interviews had more the qualities of a talk rather than final interview questions for students on which to make a statement. The aim was to highlight student ideas about physics lessons. This paper aims to show how specific personal ideas of students, their experiences and questions also give the teacher/interviewer opportunities for a conversation that is interactive/dialogic.

The pattern for the transcribed student/interviewer conversation showed partly exploratory talks (Barnes & Todd, 1995, Mercer, 1995, 2000). The paper presents six students’ personal ideas developed during the exploratory talk parts of the conversation. The focus of the analysis is how the talk, around 20 start questions, elucidates students’ personal ideas after prompting utterances from the discussion partner/interviewer. The research questions are: 1) What kind of personal ideas do the students bring into the discussion? 2) What ‘unexpected’ questions and utterances does the discussion partner/interviewer prompt the student with to get deeper into the student ideas?

Methods and samples
One month after their physics course the students were invited to take part in the interviews/talks and were informed about the research purpose. The teacher was informed about the interviews/talks going on. The class had been divided earlier into two parts and to be able to handle the interviews only one of the groups was invited to the interviews/talks, and 13 of the 16 students came as volunteers. The interviews were open-ended around a few themes that all students responded to. The themes were 1) the student’s experience from the different physics courses in school, 2) the student’s experience from the last physics course that included lectures, two laboratory sessions and three sessions with small group work with context rich problems, 3) ideas about group work and laboratory work, 4) learning physics and 5) remembering physics activities. An interview guide was developed with 20 questions to have as support to the discussion partner/interviewer to get the conversation going. The conversation was tape-recorded and six were completely transcribed, the others partly.

Results
So far the analysis of the first six transcriptions has been done. The starting questions from the interview guide were located (if used) in the transcript, and the discussion partner’s/interviewer’s ‘unexpected’ questions and utterances were looked for. The student driven exploratory talk driven was identified. The second starting question was ‘How do you look upon physics lessons?’ Some results of how the students’ specific personal ideas come up are given in examples below.
Example 1 Student C
Student C is very verbal; the discussion around this first situation question is three pages in the transcription. The first main student-driven idea is about *the limited time* she has felt during all her physics courses in school, as well as in this first course at university. In the exploratory talks, the interviewer prompts the discussion with the words ‘*...and what is it then you would have liked this time for…*’ that keeps the discussion going.

Her second main idea is about how *physics is analogous to a sport*. The responding question from the interviewer is: ‘*What is the aim with the sport physics then…*’

The student than expresses, in half sentences, in the typical explorative way:

Interviewer:  What is the aim with the sport physics then....
Student C:  What is the aim with the sport physics...well...it is maybe to ...learn how to ...you get another type of thinking ...if you say so ...well... some issues are taking for granted...if you learn physics then you see things from another side and of life also...you notice that ...planet Earth... not ...well, you are not alone here... so it is so... so much...with physics you reach answers to so many questions...you can get answers to how things work but not why they works...and that is a bit frustrating...or why it is as it is but it is more scientific this way... sometimes it is good to know how things work ...it is annoying not to know how...

Example 2 Student S
Student S has had difficulties with the course and did not pass the final examination. His main idea is *how the context is much more important* than calculations and all details about the formulas. In the exploratory talks the interviewer prompts him to continue develop his ideas with the words ‘*...What do you mean with context here…?*’ and he explains:

Student S: I find it more important to understand the context than to know some formulas to make calculations with. That is what I say.

Interviewer: What do you mean with context here ...?
Student S: If we have a chapter with …as sound or anything … thermodynamics ……that is much …I rather understand the wholeness and draw my own conclusions from that than I have five six different formulas to use with different values and …if I understand without …of course it is good if I understand the formulas too, but... if I understand the whole situations I find that better

Interviewer: Do you manage without understanding the context?
Student S: No, you don’t.

Summary of other student ideas and prompting questions
Student K finds physics *interesting*, and elucidates after the prompting question ‘*What do you mean by it is interesting?*’ with the addition ‘*if it helps to make you understand how things work.*’

Student G needs some more encouragement and help to be able to express that *physics is fun* as long as you understand, and *that physics teacher has to help students get interested*, so they are motivated and able to relate physics to reality.

Student T has her own ideas about *calculate things*. To explore this she is asked: ‘*do you think there is a special way to see the existence when you have studied physics?*,’ and she continues definitely that she knows *how to calculate most things, only if she thinks about it, it is fun.*

Conclusions and implications
Several of the 20 starting questions gave openings that developed a talk that was exploratory and interactive/dialogic. The way to prompt the students with supportive questions and encouragement helped them to reach a deeper meaning and expression of their ideas. It is important that the tutor is aware of, and listens for, the students’ personal questions and ideas, and to prompt the student to explain more, and in more detail, about these ideas, as they are keys; both to good talk, and to students’ increased understanding and development.

There are several ways to look at teacher/student talk. One is to see conversation as a tool with which the teacher orchestrates the lesson, and by that an obligation for the teacher to be aware of the importance of the different classroom talk qualities. Analyses of classroom talks using the communicative approach (Mortimer & Scott, 2003) shows that most talk in the classroom is driven by the teacher, an authoritative/interactive talk, where teachers give questions and evaluate student answers. Dialogic/interactive talk, where students give their views of physics-related topics, is a rare thing in the teacher/student talk in the classroom. A second way to look at teacher/student talk is the possibility of changing physics discourse, from a content point of view, for the benefit of student ownership of learning, and for the culture of physics in school. Emphasizing more talk in the classroom raises hopes for enhanced physics teaching and increased student co-operation and ownership of learning (Enghag, 2006). This way of taking time to find out about a student’s personal ideas and individual views is a useful instrument. Dialogic/interactive talk can also be used in tutoring if staged in the classroom with several students and with physics concepts in focus.
A discipline-oriented focus on the links between research and teaching at a research-intensive university: the case of physical geography

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Carl Winsløw

Background, aims and framework

The aim of this study is to analyze the interplay between teaching and research as experienced and described by professors of physical geography at a research-intensive university. In doing so we focus on the role of disciplinary knowledge structure as a crucial condition for the relations between research and teaching in higher education, as enacted by practitioners. Thereby this paper forms part of a growing body of literature (e.g. Blackmore, 2007; Healey, 2005; Healey & Jenkins, 2003; Neuman & Becher, 2002; Robertson, 2007; Scott, 2005) that acknowledges discipline as a crucial factor when trying to grasp and develop the links between research and teaching.

Healey (2005, p. 186) talks about the discipline as “an important mediator” in enhancing links in order to benefit student learning. Robertson (2007, p. 550), in her study of New Zealand academics, found it ‘impossible to avoid the overwhelmingly disciplinary nature of the variation revealed in academics’ narratives’. By focusing on one discipline we hope to unfold some of the complexity of the relations between research and teaching and take the research area towards a perspective of didactical design for further development of university teaching in physical geography and related disciplines.

Methods and samples

The paper draws on a research project focusing on both mathematics and physical geography (Madsen & Winsløw, in press). In this project we develop and explore a theoretical model of the interplay between university teaching and research within a scientific discipline, in order to be able to design and analyse a study of how professors describe these activities, and how this depends on discipline specifics. For this purpose we modified the so-called 4T-model from the anthropological theory of didactics (Barbé, Bosch, Espinoza & Gascón, 2005; Chevallard, 1999). In short, the framework allows seeing the respondents’ practice of research and teaching as so-called praxeological organisations. These organisations are structured families of praxeologies, each consisting of a practical block (type of task, corresponding techniques) and a theoretical block (the theoretical discourse and justifications). Taking the discourse of respondents as our data, three other levels can be described by the questions: What is to be done? (type of task), How is it done? (technique), And why is it done so? (theory behind). For further details of the framework see Madsen and Winsløw (in press).

This paper reports on the geography part of the study, based on five qualitative interviews with researchers at the Department of Geography and Geology at the University of Copenhagen, conducted in the first half of 2006. The interviews lasted 1-1½ hours and were semi-structured. They centred on three distinct parts: research, teaching and the relations between them, with a focus on the individual respondents’ experience and views, arising from current practices. The questions were organised according to the theoretical framework. We first asked the respondents to select a recent research project and the questions dealt with the ‘what’, ‘how’, and ‘why’ of this praxeological organisation (based on research tasks). Along the same lines, we then focused on a recent undergraduate course taught by the respondent (the ‘what’, ‘how’ and ‘why’ of a didactical organisation, i.e. organisations of practice related to teaching tasks). These first two parts then supported a discussion of the relations between research and teaching, as references could be made to concrete instances of the respondents’ current activities both by the respondent and by the interviewer.

All interviews were taped and later transcribed in Transana-MU, version 2.12 (Woods & Fassnacht, 2007). We coded the transcripts independently according to the theoretical framework, and afterwards compared. The reliability of the coding was high.
Results

The respondents give rich descriptions of their research and teaching practice at the level of practical blocks (types of tasks and technologies used). They describe and elaborate on what they do and how they do it. However, in relation to creating links between research and teaching, it turned out that it was much easier for all the interviewed researchers to reflect on techniques than on theory blocks. For example the respondents describe that as a researcher who is teaching, you are able to see what content you need to bring into the teaching:

You have a temperature curve that shows an impact on another parameter, there is a relation between radiation and temperature, that you have found in your research and that you bring in. In that way we get material in (respondent 3).

Reflections on why it is done so (the theory block of teaching praxeologies) appear more limited. In particular, we found little systematic reasoning about teaching practice or its relation to theoretical blocks of didactical organisations, and instead much reference to personal experience and traditions. Further, in line with Robertson (2007), we found that the geographers had a strong image of a continuum with regard to their activities in research and teaching, especially as regards advanced levels of teaching.

In our analysis two types of metaphors turned out to be very persistent within the empirical material: the discipline itself is seen as horizontal and the roles of the participants within the discipline appear more vertical (or hierarchical).

As to the first metaphor the geographers do not actually describe the structure of their study programme as horizontal, but looking at their descriptions of teaching practice (and at the programme itself) it is justified to consider it to be so. By a horizontal discipline we mean one where different research organisations live side by side, sometimes interacting, but not drawing on each other as strict prerequisites. By contrast, in a vertical discipline, extensive prerequisites are needed to access a modern research organisation because techniques and theories are built up in cumulative ways. The comparative aspect of the whole study – involving also mathematics – was crucial in bringing out this particular aspect.

As to the second metaphor, it can be exemplified through the history of a research project based on the following idea:

The idea stems from the fact that I teach at the university on Svalbard … what triggers me is that the heap seems warm in winter. Measurements show that the heap is warm and that makes me set up the working hypothesis that what has been believed up to now – that the summertime is the most important period for studying the strain on plants by heavy metals – is false; it's the wintertime (respondent 2).

Two colleagues, five master's students, and one Ph.D. student had been involved in the research project. For 'respondent 2', substantial work has been devoted to organising the fieldwork periods, to secure that measurements were taken continuously, and to apply for research permissions and funding, correspond with relevant authorities, and organise the data processing with students and colleagues. This way of organising the research activity can be described as vertical, because the whole activity is led and coordinated by the senior researcher, but allows – even necessitates – the participation of students at various levels of the execution.

These two types of metaphors of the discipline of physical geography can be used to understand how student activities relate to research activities. Due to the vertical structure of the research activity the students are at times important co-agents in research due to the need for data collection. Further, the horizontal structure of the discipline allows students to actually participate in research practice early on in their studies, involving them in the solution of research tasks based on scientific techniques.

Conclusions and implications

Interviewer: So they go through some of the same steps as you do when you are researching?

Respondent 5: Yes they do. They must search for knowledge and they also need to go through that stepwise process from an idea – we have an idea and then we need to search if there is data for it and … – find data and then need to wonder about the results and … the report of the results is just like a research paper.

Many similar quotes from respondents suggest a highly developed integration of teaching and research, strongly influencing student activities. This may be explained by the discipline's horizontal character and vertical distribution of roles within the research process. However, we found little explicit awareness among the researchers of the significance and justification of the didactical organisations (corresponding to their theoretical block). This means that the links between research and teaching do exist and influence student activities, but also that they may be vulnerable in times of change. Therefore in line with Robertson (2007) we see a need for an epistemological ‘meta-awareness’ to make explicit the structures of disciplinary knowledge among the involved parties, and to further explore how these structures shape the links between teaching and research in higher education within different disciplines.
References

Blended learning as a basis for an in-service training concept in natural science
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Background
This paper reports on experiences with the NOFAN project (Upgrading of Qualifications in Natural Science through Subject Related Teaching – Activity Centre and Network Formation).

Blended learning/flexible learning is understood as a combination of synchronous face-to-face teaching and asynchronous teaching based on net-based courses through a groupware system. Such a course can be supported by various pedagogical approaches to obtain optimal learning benefit (Georgsen, 2004, p. 15). Based on a desire to further qualify the teachers in natural science on Lolland, Falster and Møn, a teaching concept was developed for teachers in primary and lower secondary school containing the following three elements:
• an academic element with a view to enhancing the qualifications of teachers in the natural science area based on blended learning,
• a network element in which bridges are built between teaching in primary and lower secondary school and local firms, and
• a practical / experimental element which supports the practical and local dimension in teaching, among other things, by developing a collection of material which will be made available to the schools in the area at the completion of the project.

The article clarifies the structure of the teaching concept of blended learning in relation to pedagogical and practical considerations and discusses benefits and drawbacks in the chosen model compared to subject teaching in traditional teacher education with the scientific subjects.

Objectives
• To develop and test a model for a flexible in-service training course which can be applied generally within the area of in-service training for people with medium to long further education who work and live in fringe areas (here Lolland, Falster and Møn)
• To explore the opportunities for working with blended learning in connection with the scientific teaching subjects.

Framework and content
Modulisering
Based on a model for modulating the subjects at Vordingborg Seminarium we split the four scientific teaching subjects each into five modules. These prepare the ground for an interaction between academic immersion and cooperation...
across four teaching subjects as a preparation for the then common test in the scientific subjects. The modules are unpublished materials and developed by teachers at Vordingborg Seminarium.

Choice of platform
Koper (2001) has said: “Most people also think that the Internet, itself, [is] the key factor in the success of e-learning. However, a vast amount of research provides evidence for the proposition that it is not the medium (Internet), itself, which is accountable for the accomplishment of these promises, but the pedagogical design used in conjunction with the features of the medium”.

In selecting a platform we valued Koper’s understanding of successful e-learning as being a result of a pedagogical process. Furthermore, we set up requirement specifications in relation to user-friendliness, as well as support of e-learning courses, with respect to cooperation between students in large and small groups.

We chose the groupware system Groupcare which met our requirements:
- User-friendliness with a limited need for training in the system.
- Connection between the students’ individual mails and the system.
- Support of group work with support of a simple communication and that the students themselves can establish groups, files etc.
- File-sharing and translation with linking between discussions and files.
- E-learning primarily as asynchronous courses.

We met with the students every 14th day and therefore did not have a need for tools for synchronous activities – the system, however, contains the option for chat, which was used to a limited extent.

Module content
Each module comprised 55 teaching lessons as well as preparation time of a similar size. The face-to-face lessons were five meetings of four hours for each module with an intervening e-learning period. The face-to-face lessons were placed at different schools in the local region to support the local dimension.

The frames for the modules were fixed through pre-formulated teaching plans that were presented to the students at the first meeting of each module. The teaching plans contained objectives for the course, content for the individual meetings as well as formulation of e-learning tasks in the individual module, including dates for assignments. Furthermore, the time of reply from the teacher was agreed upon. Content and framework of the modules for the first course was developed in a study group including the teachers involved (Andresen, 2001).

The modules were evaluated on the basis of oral and written remarks from students as well as written evaluations from the teachers.

The content of the modules was based on the learning theories outlined in Table 1 and can be related to Qvortrup’s thoughts on knowledge hierarchies (Qvortrup, 2002): “One forgets that knowledge exists in hierarchies. One cannot develop knowledge reflexivity competence without possessing a great measure of factual knowledge, and one cannot work scientifically or creatively without comprehensive academic ballast”.

E-learning
We formulated e-learning tasks in accordance with Bent B Andresen’s definition, paying attention to the following (Andresen, 2001, p. 56):
- e-learning can be lonely for the student and requires a lot of self discipline
- it can be hard to establish a socially binding environment amongst the students
- e-learning requires fixed frames with among other things clear objectives for the course, clearly formulated tasks, clear agreements for handing in assignments and time of response from the teacher.
- e-learning is based on written communication which is time consuming and a hindrance to many (Videnskabsministeriet, 2003).
Table 1  The learning content in three phases in a typical NOFAN module put in relation to learning theories

<table>
<thead>
<tr>
<th>Learning theory</th>
<th>Start phase</th>
<th>Middle phase / end phase</th>
<th>End phase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning content</strong></td>
<td>Controlled Structured course Individually</td>
<td>Independently Flexible course Individually/groups</td>
<td>Independently Flexible course Individually/groups</td>
</tr>
<tr>
<td><strong>Relations</strong></td>
<td>Presentation and training Control with subject and teacher From teacher to student.</td>
<td>Guidance/coordination Control between student and teacher Between student and teacher.</td>
<td>Guidance/coordination Control with the student Takes place between students</td>
</tr>
<tr>
<td><strong>Example Geography: Module 3 Cultural Geography</strong></td>
<td>1st meeting: Presentation on primary occupations 1st e-task: Theoretical task concerning analysis of statistical material and literature handed out</td>
<td>Three meetings with varying student activities, field trips and teacher presentations. e-tasks in groups on energy as a topic in school, field trip preparation and recapitulation related to field trip to Copenhagen</td>
<td>Preparation of final plan of content and group based presentation.</td>
</tr>
</tbody>
</table>

In order to deal with the feeling of loneliness, a social network was established in each class as well as lowering the requirements for written communication if fixed groups were established by students from schools in the same area.

The actual e-learning tasks were formulated in accordance with Kolb’s circle of learning (Figure 1) which describes learning as a four-step process. Kolb (1984) identified the steps as (1) watching and (2) thinking (mind), (3) feeling (emotion), and (4) doing (muscle). The tasks as far as possible were connected to concrete experiences in the form of field trips, examinations, exercises, and experiments or similar activities.

![Figure 1  Kolb’s circle of learning](image-url)

**Evaluation**

The modules were evaluated on the basis of oral and written comments from students in order to clarify the students’ assessment of the module courses as well as written self evaluations from the teachers in the form of reflections over the content of the modules and the course – both the e-learning courses and the face-to-face teaching.
The module evaluation was also based on the students' portfolio comprising written subject didactic content plans which had been presented in class. A content plan is the student's thoughts on how the academic content of the modules can be included in subject teaching in primary and lower secondary school. This among other things includes thoughts on academic key concepts, methods, progression and possible integration with other subjects in the school. The teachers' self evaluations could form the starting point for discussion on differences and similarities in the approaches of the different natural science subjects in the modules and this became a part of our communal "learning from each other."

Quotes from the self evaluation documents are included in the following paragraphs as part of a comparison with traditional teacher education.

**Comparison to the corresponding course in traditional teacher education**

The NOFAN modules are built up differently than the semester plans of the teacher education. Still, it is possible to make a comparison from the comments from the teachers involved:

**Biology:**
NOFAN students who have held out during the first 2 modules are generally very focused as the course requires high self discipline and high work ethics.

**Physics/Chemistry:**
There is a noticeable difference in how a NOFAN-student presents and how a student teacher does, because a NOFAN-student is used to teaching and has practical references to the course.

**Geography:**
The just 20 lessons of face-to-face teaching in each NOFAN module means that often a lot of content is squeezed into the meetings. This means that some open discussion, exercises and reflections are excluded which are a natural part of the lessons in the teacher education.

**Natural Science:**
The rather few times for face-to-face sessions with intervening e-learning periods make demands on the discipline of the students. The practical exercises on the way are left to the students themselves to a great deal and given that they have experiences with the topics from teaching in schools, this works reasonably.

All in all it could be said that an "ordinary student" more easily can be inactive, whereas the e-learning tasks makes inactivity in the studies very visible. Furthermore, the work with the e-learning tasks creates a high degree of self activity which is incredibly important in a learning process.

The very compressed face-to-face courses mean that practical activities as well as time for common reflection are given a low priority in blended learning compared to traditional teaching.

**Conclusion and recommendations**

In a course with blended learning we have to qualify and prioritise content and activities in the meetings so that there will be room for discussions and practical activities. In the teacher education we can let the students solve tasks that resemble the e-learning courses in NOFAN.

To ensure communication and dynamics in the e-learning courses, it is important that groups do not move below a certain number of students.

In addition, it is recommended that there is a fixed co-ordinator who follows the group during the whole course to ensure stability and increase the security which in connection with e-learning is very important in encouraging students in the group to communicate electronically.

In the NOFAN project a new concept for in-service training has been developed which can be transferred to other parts of in-service training in our organisation. We can now offer a cost competitive, flexible teaching proposal which does not require to a great extent that the course participants are pulled out of their daily schedules. The concept can be transferred to other subject areas and education areas and is not restricted to natural science content.

NOFAN has also meant that we can offer natural science in the teacher education as an e-learning course.

**References**

Science teacher professional development in new programmes in Germany and Denmark

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Background, aims and framework

As a response to poor performance in student assessments of science and mathematics, efforts have been made to improve science and mathematics teaching. In Germany the SINUS programme (‘Increasing the efficiency of science and mathematics instruction’) started in 1998. From 2002 on a triad of “in context” programs was launched: Chemistry in Context, Physics in Context and Biology in Context. These programs are now in their second phase. After validating the strategy and improving the main ideas, the programmes now have expanded to involve teachers and types of schools which had not been involved before. In Germany more than 8000 teachers took part in these programmes.

Since November 2006 the Centre for Science and Mathematics Education at the University of Southern Denmark has conducted, as a pilot project, “Science Teachers of the Future”, an education programme in mathematics and science education for in-service lower secondary school science teachers. The aim of this pilot project is to develop and implement a master’s degree program. On the basis of the results of this pilot project, the Danish accreditation council has now approved the program as the first master’s degree programme in mathematics and science education in Denmark. The programme is organized as workshops and open seminars with the purpose of making it possible for teachers to share their ideas and experiences with their colleagues and having contacts with academic experts in the fields of science and mathematics and educational research. The pilot project began with the participation of 24 science and mathematics teachers.

The German and the Danish programmes involve the teachers in design, implementation and evaluation of innovative instructional sequences, which deal with a wide range of aspects of mathematics and science, e.g. modern science and the importance of science in society. Contemporary science and mathematics education research serves as a basis for the design and development of warranted practices with which the teachers may experiment in their classroom.

The educational reconstruction model developed by Kattman, Duit, Gropengießer, and Komorek (1996) provides a didactical tool for designing, implementing and validating the instructional sequences. The model consists of three main components which mutually interact: First, analysis of the content structure (including the educational viewpoint); second, the execution of empirical investigations which at first have explorative character; and third, the construction of instructional units. These three components are supposed to stimulate each other in an interactive and cyclic process. Sjøberg’s (1997, 2004) three dimensions of science and mathematics serve as a framework for the selection of content of the instructional sequences: (1) the products of science and mathematics; (2) the processes of science and mathematics; and (3) the role of science and mathematics in society.

Teachers exercise considerable control over the decision of whether and how to implement a change in teaching practice, and any intervention should acknowledge this control, and help teachers understand and be held accountable for the intervention (Richardson & Placier, 2001). With the rationale of supporting teachers in participate in ing and
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contributing to the process of improving science and mathematics teaching the programmes are organized as workshops and open seminars. This makes it possible for the teachers to share their ideas and experiences with their colleagues in teams and be in contact with academic experts in the fields of science and mathematics and educational research. The aim is to create a new culture of teaching, mainly to break the dominance of the Socratic method of questions and answers. Students should have an active role in the classroom work by opening the chance to participate in planning as well as in “researching” in the given science contexts. The process follows activity theory and shows the characteristic elements of professional development as observed in other professional teams as described by Engeström (2005).

**Methods and samples**

In all 24 teachers participating in the Danish programme and 21 teachers from SINUS and Chemistry in Context (ChiK) were interviewed. The interviews were semi-structured and consisted of specific questions aimed at determining what impact on their professional identity the teachers expect from the programme, motivation to change their classroom teaching and willingness to engage in a network of teachers and educational researchers.

In Denmark the interviews were conducted at the beginning of the pilot study, in Germany after one year of Chemistry in Context and after two or three years in SINUS.

In Denmark, also, all teachers wrote a two-page essay where they reflected on five components in the teacher’s self: (1) self-image, (2) self-esteem, (3) job motivation, (4) task perception and (5) future perspective. A follow-up of the interviews and essays will take place at the end of the pilot study. During the workshops and meetings of the programme the teachers reflected on their work and received feedback from their colleagues and the educational researchers. Researchers who took notes observed these discussions.

In addition to the interview-study, the programmes are evaluated in large scale by researcher-groups through questionnaires. This gives a background for the detailed research we did.

**Results**

We present some of the experiences with the Danish pilot project and the results of the German interview study. We will focus on the outcomes of offering a program which is intimately tied to (i) contemporary science and mathematics education research, (ii) modern science and mathematics and (iii) the teacher’s practices in the classroom. In particular, we will elaborate and evaluate the involvement of the teachers in ongoing educational research projects *vis à vis* the strategic aims of the master’s degree program.

Figure 1 shows the attractiveness of collaboration and of participating in developing new ways of classroom teaching. The participants worked one to three years in the programmes. Figure 2 shows how fast the effects of collaboration are established. During the period of the pre-post interview we could not see a greater extent of collaboration, so the positive effects must have been reached in the first period of participation.

![Figure 1](attractiveness_collaboration.png)  
**Figure 1** Attractiveness of participating in SINUS and ChiK (n=21).
Conclusions and implications

The main results support the design and strategy of our programmes. It was possible to break the isolation of teachers and to establish small teams. The teachers considered the close contact with academic institutions a promising possibility to improve their professional knowledge about teaching and learning and to use contemporary educational research to improve their teaching. However, some of the borders are not easy to conquer, for example, the problem of the lack of content knowledge of the teachers. We established a series of training sessions in chemistry teaching for the members of our group, but still there is a lot of work to be done.

Ongoing projects involving science and mathematics education researchers, such as the PARSEL project, offer unique opportunities to develop the in-service teacher programmes further in a European context based on the experiences from the SINUS programme, CHiK and the Science Teachers of the Future project. The success of the programmes and the knowledge gained from them depend in part on being able to sustain the partnership between educational researchers and teachers. This calls for the cultivation of the ongoing relationships between the teachers and the researchers.

References


Authentic learning situations for teachers – perceptions of and gains from in-service courses in space technology

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Background, aims and framework

Major resources are put into in service courses for teachers, and it is hence important to learn more about the quality and potential success of such courses. This study explores the long-term effects of in-service courses in space technology for teachers, arranged at the Andøya Rocket Range (ARS), Andøya, Norway. The focus is on how individual teachers perceive
their gains from the courses and the factors that contribute to their gain.

Evaluation carried out at the end of the stay at ARS showed that the participants were very content with the course and its outcome. A questionnaire survey performed 4-12 months after the end of each course showed that the positive evaluation was also a long-term phenomenon (Mehli, unpublished data, 2007). The participants were still very content with the course and what they had obtained. The teacher’s responses indicated:

- increased subject matter knowledge
- more motivation for teaching relevant topics in school
- that the course had given them exciting challenges
- that their newly gained competence had been used actively in their teaching

All in all, the course seemed to have been useful and the teachers claimed to have profited in several ways.

The purpose of the present study was to investigate the apparently successful in-service courses. When trying to understand what teachers gain from the courses in a broader perspective, the concept of science education as an authentic practice has been applied. This concept has evolved as one response to challenges related to the traditional science curriculum. The subject is seen as suffering from lack of relevance, decontextualization of presented knowledge and lack of connections to science as an enterprise in modern society (Gilbert, 2006; Millar & Osborne, 2000). Some of the approaches to science education draw on a view of knowledge as ‘situated’, that is, in part a product of the activity, context and culture in which it is developed and used (Brown, Collins & Duguid, 1989). This means that the context of learning is not only a ‘wrapping’ of the content to be learnt in order to motivate or facilitate the learning process, but an important component of the learning outcome itself.

Situated learning can be related to what it means to learn within ‘communities of practice’, as knowledge viewed as situated is socially reproduced and developed (Wenger, 1998). For newcomers in the field, participation in the community of practice forms their knowledge in the field as well as their identity of belonging to the community.

With these ideas in mind, the research questions for this study were as follows:

- What characteristics of the courses were important for the positive outcome from the teacher perspective?
- How do the teachers respond to elements of authentic practice implemented in the in-service courses at ARS?

Methods and samples

The courses investigated are five in-service courses for physics and science teachers arranged by NAROM (Norwegian Centre for Space-related education) and NTNU (Norwegian University of Science and Technology) during 2005-2006. The participants were science teachers in primary, secondary or upper secondary schools, and had varying educational backgrounds. The courses covered topics such as space research, the atmosphere, and energy in space, rockets and satellites, given as lectures, exercises and laboratory work. Practical activities were performed in groups consisting of teachers and researchers/engineers. All the participants stayed at ARS for a week, together with engineers, scientists and lecturers. They had unlimited access to technical equipment during the course.

This study focused on the positive outcome of the in-service courses and the factors contributing to it. Teachers were reported high gains from the courses were interviewed in order to learn more about why these courses had worked well for them, why they felt the courses had been so constructive in their professional development, and what they thought they had obtained. The informants were therefore selected according to the following criteria:

1. Teachers in upper secondary school, where the content of the courses would fit the best
2. Participants who reported that they had used parts of the course to a large extent in their own teaching
3. Teachers who were teaching science or physics classes at the time.

Eleven teachers, all from different schools in different parts of Norway, participated. The interviews were semi-structured, with several questions about space as a topic in school, how they perceived the course they had attended, in what ways they had been able to use elements from the course and what they felt had contributed the most to the perceived gains. The interviews were transcribed and analyzed. For this paper, the informants’ own words about their gains, their response to the question “What factor contributed most to the positive experience?” were of particular interest.

Results

When asking the teachers what they thought had contributed the most to their gains from the courses, they all understood gain as “what was most important for my learning”. In this respect, the teachers interpreted “learning” as increased subject matter knowledge, rather than curricular content knowledge and pedagogical content knowledge (Shulman, 1986). Teachers responses to what had contributed the most can be grouped into five main themes:
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1. Working with professionals: People who are experts in their field come there and talk to you, do practical exercises with you, eat dinner with you!
2. The practical activities: The practical exercises – we got to do things ourselves!
3. Time and opportunity to work: A full week gave us time to go in depth, learn more, see different topics in context.
4. The surroundings and facilities: I think it is all connected, what you see, what you do, the surroundings, experiments and lectures. Just being there, see how things really work!
5. Doing something “real”: Firing a rocket – and understand that manual work and common sense is still important. Like when dealing with how to fit the payload into the small available area in the rocket.

In summary, the surroundings were mentioned as important for the learning outcome, being in a working place where real research was performed, getting to use advanced technical equipment, working with engineers and researchers and getting to know them. All these are characteristics of participation in the communities of practice within an authentic research site such as the rocket range. All the teachers were enthusiastic about the place where the courses were held and the way they were treated while they were there. They appreciated the professional level and the totality of the course that initiated learning.

In Garet, Porter, Desimone, Birman and Yoon (2001) the most important success factors for professional development among maths and science teachers are reported to be i) intensive and sustained development ii) focus on subject matter content iii) opportunities for “hands-on” work and iv) integration in daily school life. The voices of the teachers in this study correspond well with these factors, as they emphasize the importance of the lecturers and the activities.

Conclusions and implications

The teacher development initiatives on space technology investigated in our study can be seen as a case of involvement in authentic practice in two ways. Firstly, when participating in the field course given at the Andøya Rocket Range, the teachers as a group have common motives in accomplishing joint projects with a specified outcome. Success in this work requires knowledge offered in the course, assistance from professional researchers and technicians on site and cooperation with each other in pursuing the project. Their short-term goal is to accomplish their course projects, while they also are likely to have common long-term goals in developing their knowledge for their science teaching that in turn will benefit their pupils. Secondly, the teachers get acquainted with an authentic practice and the community of professional space scientists in working together with them during the course, using their research facilities and also engaging with them socially. They participate in the social as well as technical contexts that constitute the authentic practice of space research and take on the various roles associated with this practice.

Brown et al. (1989) have argued that schooling too often is based on the idea that knowledge can be acquired in one context and then transferred to and applied in any relevant context in work life and society. Education hence deny students the chance to engage in the relevant domain culture, being shown the tools of many academic cultures while not providing access to the culture in which this knowledge is developed and used. With the importance of teachers for the student knowledge development in mind, it seems obvious that teachers also must have access to knowledge of the relevant cultures of working life.

In a situated view, knowledge can be characterized as dynamically constructed and articulated within a social context, and manifested in various ways according to the area of expertise (Clancey, 2008). The in-service courses at Andøya had many similarities to a situated learning situation. The context of learning and the surroundings at Andøya appeared to be important components of the learning outcome itself, creating an environment where the participants became a part of a community, learning from each other and from experts.

The main focus in research has been on student gains from participating in authentic learning situations. Etkina, Lawrence and Charney (1999) reported enhanced content knowledge and improved authenticable practice of science among students serving as apprentices to university professors. The results of the current study indicate that authentic learning environments are important also for teacher learning in in-service education programs. This is in accordance with other results (Melber & Cox-Petersen, 2005), where teachers taking part in museum workshops showed increased content knowledge and better understanding of the process of fieldwork. Participation in programs involving subject matter knowledge, activities and authentic scientific environments seems to be important for the teachers using acquired knowledge in their classrooms. It is important that these aspects are taken into account in the planning of such programs.
References

Train, teach; taught? How the content of specific science subject matter knowledge sessions impacts on trainee teachers’ classroom practice and children’s learning

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Background, aims and framework
This study assesses the impact of sessions (Appendix 1) oriented towards subject matter knowledge (SMK) and PCK (pedagogical content knowledge) on the classroom practice of trainee secondary science teachers and children’s science learning. The project involves collaboration between a university department of education and a secondary school. Our research questions are:

1. How do trainee science teachers use sessions designed specifically to develop their SMK and PCK in planning and teaching their lessons?
2. In what ways do these sessions impact on children’s learning?

Provision of qualified secondary science teachers is a topic of international interest (Abell, 2000). This study explores the effectiveness of a collaborative model for science teacher education involving university lecturers and experienced science teachers. The approach and findings are likely to be of interest to the international community.

In our context, gaining qualified teacher status (QTS) in England and Wales requires graduate scientists to complete a thirty-six week Postgraduate Certificate of Education (PGCE) course at a Higher Education Institution (HEI). Twelve weeks are HEI-based, while twenty-four weeks comprise “teaching ‘practice’ in two different schools. The participants, “trainee” science teachers, hold degrees subjects related to biology, chemistry or physics. They teach all sciences to 11-14s and often, to 14-16s.

Potential gaps in SMK exist. To address these, sessions are provided in the HEI-based period, divided into two types:

- 12 are SMK-oriented, led by university lecturers, related to specific topics in the Science National Curriculum (DfES, 2004)
- 6 are PCK-oriented, led by experienced school teachers at our Science Learning Centre (see White Rose University Consortium Team, 2005) focusing on teaching topics taught commonly to 11-14s.

The present study contributes to the evaluation of this model. The timeline for the project is outlined in Appendix 2. The project is funded by a research grant from the Training and Development Agency (TDA).

Possessing “good” SMK is widely accepted as key to teacher effectiveness (Geddis, Onslow, Beynon & Oesch, 1993; Lederman, Gess-Newsome & Latz, 1994). Teacher education programs reflect this, offering sessions designed to help shore up potential weaknesses. Unsurprisingly, some trainees may sense panic when teaching science topics with which they are unfamiliar, gaining support from being told “what to teach” (Kind, 2007). However, teaching is more than possessing good SMK: Shulman (1986a, 1986b) proposed that teachers “transform” SMK using PCK, a powerful model that has been re-interpreted widely (Carlson, 1999; Magnusson, Krajcik & Borko, 1999; Marks, 1990). Hence, trainees also need to learn to take their first steps in ensuring this, a process normally occurring on “teaching practice”. Inevitably, trainees’ ability to transform SMK to PCK varies, with consequent variation in their perception of what constitutes a “successful” lesson (Borko, Lalik & Tomchin, 1987).
Besides these SMK related issues, evidence indicates that specialized support helps trainee science teachers develop positively (Luft, Roehrig & Patterson, 2003). Thus, provision of SMK- and PCK-oriented sessions taught by specialists may assist trainees’ skill and knowledge development.

Methods and samples
The study takes a qualitative, multi-method approach.

To answer research question No. 1
A questionnaire comprising closed and open questions probed trainees’ views. Trainees commented on how training sessions influenced SMK preparation and provided pedagogical strategies, indicated how session materials were used, indicated constraints placed on use of session materials and described significant influences on their PCK and SMK development.

To answer research questions No. 1 and No. 2
We devised a “Video-Interview-Interview” technique, involving video recording science lessons and interviewing trainees about the lesson, and interviewing children about their learning (Appendix 3).

Samples
42 trainees participated in the study. All completed the questionnaire.

Three trainees participated in a Video-Interview-Interview. One lesson for each was video-recorded. Trainees were interviewed about their preparation for teaching and their beliefs about the “success” of the lesson. Six - eight children participated in group interviews after each lesson.

Data analysis
Video data were analysed by Atlas into sequences that corresponded with the trainees’ lesson plans. Dialogue was analysed for teacher statements that involved explanations of science concepts relevant to the topic, and for pupil comments that reflected understandings.

Interview data were analysed by Atlas into sequences that corresponded with video evidence. That is, where a trainee commented on an event occurring in the video, a match was made. The same procedure was undertaken to make connections between video and interview data for the children.

The questionnaire data were used to provide supporting evidence from the cohort as a whole. Closed question responses were counted and open question responses were analysed by qualitative methods to produce coding schemes.

Results
Trainees’ backgrounds: 22 had degrees in biology (or related subjects), 13 in chemistry and 7 in physics (total: 42). Their average age was 27.

The questionnaire revealed:
- 22 trainees found physics-based sessions most useful for developing SMK
- All trainees perceived all science sessions as opportunities to develop SMK
- 34 (about 75%) of trainees believed teaching skills developed most while on teaching practice
- 33 (about 75%) of trainees used session materials for revising SMK, or in a lesson.

Some trainees said they could not use session materials in their teaching practice schools because: lessons plans already existed in the school and no new ideas were allowed; poor facilities for practical work or ICT reduced opportunities; trainees did not teach topics featured in the sessions.

Video-Interview-Interview data revealed trainees’ lessons to be well-planned, providing two or three activities. Children behaved well. Trainees described activities confidently and helped children complete these.

Trainees’ interviews revealed that when preparing lessons, they looked for activities that children could complete easily. Trainees regarded a lesson as “successful” when children completed activities in a good working atmosphere. All three used session materials at some point, but not in the video-recorded lessons.

Video recordings and trainees’ interviews revealed that all three trainees missed opportunities to explain key ideas. For example, one trainee taught classification of organisms, giving children an activity that involved producing their own classification schemes. She then presented “the correct scientific classification scheme”, without explaining why scientists use only one scheme. Differences between the children’s schemes could have made this clear. She believed the lesson
was successful because children had completed their tasks well, without misbehaving.

The interviews with children revealed that they value individual attention most of all; appreciate “knowing where lessons are going” and “how lessons link together”; prefer direct input, “telling things as they actually are” and get a sense of achievement from learning difficult things.

Conclusions and implications

**Question 1**

Trainees’ and presenters’ perceptions of sessions differ. The intended distinction between SMK- and PCK-oriented sessions was missed (Appendix 2): trainees saw all sessions as opportunities to develop SMK. They stated that teaching skills would develop on teaching practice.

Uses of sessions were limited, but varied. Constraints placed on some trainees’ teaching opportunities by schools meant that materials could not be used. Instead, trainees mainly used resources from their teaching practice schools.

**Question 2**

Impact on children’s learning was difficult to trace. We think this is partly because we only used one strategy to collect data from children – we were testing the best way for doing this. Also, trainees did not teach for understanding specifically, but focused on activity completion and good behaviour. Trainees did not notice this at the time, but became aware during their interviews and through hearing the children’s interviews. The interviews revealed that children are prepared to work on difficult ideas, and show positive attitudes towards science.

**Training science teachers**

Preparing sessions that meet both trainees’ expectations for SMK input and presenters’ pedagogical standpoints of interest is difficult. More detailed clarification of aims and objectives for lecturer- and teacher-led sessions may help. However, we may also revisit session structure and content, given that trainees perceive all as SMK-oriented, making limited use of materials when teaching. That trainees tend to focus on description and activity completion rather than achieving genuine understanding is perhaps unsurprising. However, if we want trainees to deliver lessons at higher cognitive levels, we must consider how best to make this explicit.

**Investigating the training of science teachers**

This study investigates a complex process – that of transforming SMK into PCK. Our next step is to refine the Video-Interview-Interview technique. We want to:

- Find alternative strategies to collect data from children – this may include individual interviews and use of specific, topic-focused questionnaires
- Improve the analysis of the video material to include “critical events” on which outcomes seem to depend, such as key explanations, interventions and pupil activity
- Feedback findings into the next teaching period so the next cohorts of trainees have a clearer understanding of the purpose for the two types of session.

This will enable clearer connections to be drawn between the planning, implementation and outcome stages involved.

**References**


Appendix 1

Differences between SMK- and PCK-oriented sessions – illustrated using biology as an example

**SMK session content summary - Biology**

Three sessions (each three hours in length) are devoted to biology topics; Survival of the individual, Survival of the environment and Survival of the genome. The sessions present a conceptual framework to develop an understanding of biology. The aim is to provide information underpinning biologists' thinking that is not always made explicit in school textbooks or in school. The sessions take a ‘systems’ approach. For example the section on ‘maintenance and change’ in the ‘Survival of the individual’ session introduces these systems:-

Chromosomes and genes; cells; whole organisms; populations and communities; ecosystems;

Each session discusses takes this approach, taught by combination of lecture interspersed with activities. An activity relating to the list above is:-

- Look up the definitions of all the systems mentioned above
- What are their main components?
- Which of these systems are most emphasised in the National Curriculum?

Students sit where they please in the sessions and work with who they wish. The aim is to ensure that everyone has the opportunity to enhance his/her SMK.

**PCK session content summary – Cells**

This three hour session begins with a 20 minute presentation illustrating what children are likely to know about this topic from primary school. Trainees are also introduced to the precise content of the National Curriculum for 11-14s. Following this, trainees are placed in five pre-organised groups, each comprising a combination of physics, chemistry and biology specialists. The groups then complete a ‘circus’ of five different experiments on the Cells theme:-

- Using a microscope – making a slide;
- Demonstration of cell multiplication;
- Making a model cell;
- Producing apple juice (using enzymes to break down cell walls to release more juice);
- Imitating the small intestine

Equipment is provided so trainees can try out the experiments and find out how to make these ‘work’, including how long they last, special ‘tricks’ to use and mistakes to avoid. A plenary discussion is held to draw out aspects such as adapting the tasks for children with different needs; key scientific ideas taught by the experiments; additional background information to include so the potential for learning is maximised.

**Appendix 2  Project timeline**

**2006**

- November  Bid to Training and Development Agency (TDA) for funding
- December  Notification received of successful bid

**2007**

- January  Discussion with trainees about the project
- February  Questionnaire to trainees designed and trialled
- March    Questionnaire issued to trainees for completion
- March    Interview questions to pupil groups designed
- April    Interview questions to trainee designed
- April    Trainees to video identified, lessons attended and recorded
- May – June Data analysed
- July     Project presented at TDA regional meeting in Leeds
- November New bid submitted for further funding
- December Notification received of successful bid
2008
January  Findings presented at the Association for Science Education Annual Conference, University of Liverpool
         Paper submitted to NFSUN 9th Nordic Research Symposium on Science Education
February  Refinements to Video-Interview-Interview technique discussed
April - May  Further data collection
June  Presentation at NFSUN 9th Nordic Research Symposium on Science Education

Appendix 3
Questions used in the group interview with children:
   1. Do you enjoy science?
   2. What do you like about it?
   3. Did you enjoy the lesson today?
   4. What did you enjoy most?
   5. What did you enjoy least?
   6. What was the lesson about today?
   7. What did you learn (that you didn’t know before)?
   8. How did you learn it?
   9. Did you know anything in the lesson before?
  10. What did the teacher do in the lesson to help you learn?
  11. What else helps you learn in science?