Planning science instruction: From insight to learning to pedagogical practices

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The 9th Nordic Research Symposium on Science Education was held in Reykjavík in June 2008. The conference theme was Planning science instruction: From insight to learning to pedagogical practice. This theme opened the way for presentations and discussions on a broad range of topics in the field of science education. The community of researchers in science education includes representatives from all the natural sciences and all levels of formal education. Increasingly connections are made to related areas, such as informal science learning, science for the public, the nature of science and relationships between science and technology. Those who presented papers at the Reykjavík symposium reflected this diversity and indeed it was often difficult for participants to decide on which session to attend. On offer was a Nordic smörgåsbord. With this publication, participants have an opportunity to go back to the table, for more of the same or to try something different.

All synopses were submitted in January 2008 and were sent to two independent reviewers. Authors received comments by March 2008 and papers which were accepted were resubmitted with changes in April. Only paper presentations are included in the proceedings.

More details on roundtable discussions and posters can be found on the conference website: http://symposium9.khi.is

Synopses of almost all the papers presented in Reykjavík are included here, with references. Most are in English, but some are in Norwegian, Danish or Swedish. A synopsis of maximum 1500 words was requested. The papers could be empirical, theoretical or positional. For empirical papers the following headlines were to be included in the synopsis:

1) Background, aims and framework  
2) Methods and samples  
3) Results  
4) Conclusions and implications  
5) References (APA 5th)

The Icelandic organising committee, under the able leadership of Hafþór Guðjónsson and active management of Kristján Ketill Stefánsson, created a memorable occasion on those long sunny days in June. Others on the committee were Björg Pétursdóttir, Kristín Norðdahl, Meyvant Þórólfsson, Stefán Bergmann and Gunnhildur Óskarsdóttir. All the committee members participate in the activities of the Science Education Research Group at the University of Iceland.

The editorial team built on the organising committee’s work and that of the reviewers and presenters and we thank Ásta Pórisdóttir and Marín Rós Tumadóttir for their role in the production of this set of proceedings.

Var så goda - enjoy this smörgåsbord of research in science education.

Allyson Macdonald  
Reykjavík, December 2008
Planning science instruction: From insight to learning to pedagogical practices

Introduction
Allyson Macdonald

Introduction
Research in science education has developed its own identity, according to Fensham (2004), who conducted interviews with 79 researchers in science education from across the world in the mid-1990s. Some researchers had started their work in the 1960s, others were new doctoral graduates. Fensham applies several criteria for the establishment of a research identity in science education. On the one hand these include criteria of substance and methodologies, such as conceptual and theoretical development, research methodology, research questions and key publications. On the other hand Fensham mentions structural criteria, including issues of academic recognition, the existence of recognised journals, professional associations, research training and research conferences. The Nordic countries meet most of these criteria. As examples, there are increasing opportunities for research training and a Nordic journal NorDiNa on research in science education was established in 2005. The Reykjavik symposium was the ninth held in the Nordic countries, with the first being held Denmark in 1982.

Fensham (2004) draws attention however to one additional criterion, the implications of research for practice. He asks whether the outcomes of research in science education are applicable to the practice of science education. This is a challenge: Does research in science education have implications for practice? Science education is not alone in meeting this challenge. An assessment of research in education from 1998-2002 in Iceland showed that academic research is not necessarily accessible or attractive to policy-makers and practitioners, and that development work in schools seldom arises directly from research (Icelandic Centre for Research, 2005).

The theme of the 9th symposium was Planning science instruction: From insight to learning to pedagogical practices. This theme was broad enough to ensure contributions from many areas of research in science education. Like Fensham, it calls attention to the need for links between research and practice and emphasises that education is not just a product but also a process. The three key-note speakers at the symposium, Phil Scott from the University of Leeds, Michael Reiss from the Institute of Education in London and Doris Jorde from the University of Oslo, were all able to keep this focus in mind as they spoke of expert teachers, learners, lessons and resources for learning.

Teaching and learning, pedagogical practices, require decision-making at several levels. Timetables and funding for resources or field-work have a lot to say about the way in which science can be taught or is taught in schools. Such decisions may be made for teachers. National priorities in science and technology and in education affect the choices open to schools and teachers.

This book begins with a brief reminder of the three key-note lectures and readers are encouraged to seek out further research by Doris Jorde, Michael Reiss and Phil Scott and their colleagues. These glimpses into the world of science education research and development are followed by a set of longer papers. In these papers we are reminded that learners and teachers have their conceptions of teaching and learning and that some concepts can be difficult to learn. The resources used in science, such as ICT, books, assignments and lab work, are all important and can both facilitate and hinder student understanding. Finally we are reminded that the provision and development of school science is not just the responsibility of individual teachers. School ethos and support for teachers are important for successful change.

Reflecting on the science curriculum
All the Nordic countries have a national curriculum, most of which have undergone extensive revisions in the last decade or two. Ralph Tyler (1948) asked: What educational purposes should the school seek to attain? This is a fundamental question for planners, school leaders and teachers. We paraphrase Tyler’s question and ask: What educational purposes should school science seek to attain? To this question we find a range of responses. Objectives for school biology include understanding the nature of the subject, world views, quality of life, and as a basis for further study. The move towards educating for competences and relating science to modern society is discussed, and cross-disciplinary work is considered effective for such understandings. Science as a career opportunity can be developed further and this includes making science attractive to both men and women. Science can play a role in education for sustainable development.
and science taught as inquiry and technology as design or innovation could be important objectives for school science. Finally it should not be forgotten that values are important in education and can be nurtured in new ways through science education. Science is indeed a complex task and here we find hopes and dreams and real ideas about what students might attain through school science.

The goal of scientific and technological literacy
A persistent theme in modern science education is the achievement of scientific and technological literacy and its importance for national development and individual well-being. The PISA studies, particularly PISA 2006, have provided Nordic countries with much food for thought. Science literacy is defined in terms of the scientific knowledge students have about the natural world and technology, what they know about science itself, how they identify and respond to scientific issues, how they explain phenomena and how they use evidence (OECD, 2007). Several of those attending the Reykjavik symposium have considered the goals of scientific and technological literacy. Socio-scientific issues are considered in several projects, including work on genetically modified plants. Student interest and motivation is important for further learning. The last two papers consider the relationship between school science and technology.

Understanding scientific concepts
There is a history in the Nordic countries of research into learning and science is no exception. The way in which learners develop their understandings of scientific concepts is still a strong area of interest in universities as can be seen from the papers delivered in Reykjavik. What is notable in this collection is the work being done not only with young students but also with gymnasium students and students in teacher education. Researchers are studying how young learners and student teachers understand questions of matter and substance, transformations of matter and redox reactions. Student understandings of aquatic life, evolution, and water transport in the human body are all being investigated and a different approach to discussing the complex concept of temperature is proposed.

Pedagogical practices
How do teachers go about their planning? Tyler (1949) would have asked: How can learning experiences be organised for effective instruction? This theme begins with papers on memorable episodes and physics as play. Research work on and in classrooms, on and with teachers, is crucial to understanding science teaching and learning, but is still not common, thus the work being done in Norway on PISA+ makes a valuable contribution not only to what we know about classrooms but also to how one might go about researching classroom activity. Research on gender issues provides a reminder that interactions between teacher and learner, and between learning environment and learner, are examples of pedagogical practice in which decisions made by teachers can have long lasting effects on learners.

Resources for learning science in schools
The PISA studies assume that teachers are only one source of information for school learners (OECD, 2005). Learning science in schools is however still one of the most visible ways for learners to engage with science. The role which resources play when teachers develop teaching sequences and learning experiences for students is debated across the world. The first paper presents the work done by the PARSEL project where the first step in a teaching sequence is not the science itself, but a situation which students need to investigate further. This widens our view of learning resources. Laboratory and experimental work is often considered to be the distinguishing aspect of science education when compared with other subjects, and this is considered here and also in one of the long papers. Using ICT in teaching and learning has not always been effective, but the papers on ICT underline real possibilities for effective use. Finally we turn to the increasing interest in the notion of ‘argumentation’. For some this might have been better placed under the theme of pedagogical practice but that may have rendered this relatively new learning ‘resource’ invisible. It is suggested that if teachers and learners are trained in the use of argumentation then it becomes a resource for learning science.

Resources for learning science outside schools
Some areas of science, such as biology and earth science, have traditionally included work outside schools. Two trends are becoming apparent; one is increased cooperation between the school teacher and the specialist at the site being visited and the other is the value of informal settings for learning science. The Nordic countries, through their fascinating geological histories, a diversity of nature in the wide range of latitudes and high level of industrial development, have a range of options for science and technology provision outside schools, both formally and informally, as is evident from the growth of science centres. In this section there are descriptions of work being carried out at the zoo, in forests, at museums and science centres and at a planetarium.

Learning to teach science
Planning instruction in science is a complex process as can be seen by all the decision-making and resources needed to build a coherent effective learning experience. Some university students learn science, perhaps for its own sake, under the guidance of science specialists while other young adults are learning to be teachers. Shulman (1986) introduced the idea of pedagogical content knowledge (PCK). He claimed that teachers need to have an understanding of general pedagogical principles, a sound knowledge of the subject being taught and a specialised knowledge needed for that particular subject. The papers to be found under this theme reflect these diverse demands made on those who teach
science or who are learning to teach science. The importance of developing subject knowledge in pre-school teacher training is presented alongside the effect of the disciplinary nature of a university subject on the way it is taught. Working with students and encouraging them to analyse and explore their own practice is increasingly important. Inservice education and the ongoing professional development of teachers is important in science education and as a research topic, given changes in the curriculum and goals for science, and new learning and teaching practices and resources.

Conclusion
The challenge from Fensham (2004) is there: Does our science education research have implications for practice? We believe it does, as will be seen in the papers presented here, but in the coming months and years, we should be diligent about this aspect of our work. We need to ask ourselves not only: What implications does my study have for practice? But also: How do I intend to connect research and practice?

It has been argued here in Iceland (Ægora, 2008) that it is the responsibility of researchers to choose problems that are meaningful for practice, to choose these problems in collaboration with policy-makers and practitioners, to carry out practitioner research and not least, to consider the implications of research findings for practice and to work actively towards making these findings accessible through relevant but diverse approaches.

References
Abstracts of key note lectures

Inquiry good...traditional bad?: Approaches to teaching scientific conceptual knowledge
Phil Scott, University of Leeds

In this presentation I will explore what is involved in teaching and learning scientific conceptual knowledge, by drawing on a sociocultural perspective on learning and presenting an analysis of the practice of an expert science teacher. This analysis will focus upon the ways in which the teacher develops the scientific content over a short sequence of lessons, through different teaching activities and related communicative approaches, thereby engaging the students both intellectually and affectively.

I shall argue that the current 'dash to inquiry approaches' needs to be tempered with careful thinking about the teaching and learning purposes of such a pedagogy. My view is that the teaching of scientific conceptual knowledge, through 'traditional approaches' is too often viewed as being necessarily transmissive in nature and therefore de-motivating for students. This certainly need not be the case, as will be demonstrated by the analysis of the expert teacher lessons. Furthermore there is a current tendency for the position of scientific conceptual knowledge to be down-played in contemporary curricula with heavy emphasis being placed on issues such as 'inquiry','argumentation' and 'how science works'. My view is that these are legitimate areas for science education to focus upon but that they are being addressed whilst the challenges of teaching and learning scientific conceptual knowledge remain largely unsolved.

The contribution of information technology to Inquiry based science teaching
Doris Jorde, University of Oslo
Wenche Erlien, The Norwegian Center for Science Education

Recent publications in Europe and the US are encouraging the use of inquiry-based science teaching as the way forward for improving the teaching of science. In this talk we will explore the definitions of what is meant by inquiry-based science teaching (IBST). Does IBST bring in new ideas into the way we teach science, and if so, what are they? How does the role of the teacher change if we implement good ideas in IBST? And what about the learner and the curriculum?

Information Technology is one of the many tools we can use in our science teaching. The talk will provide examples of how information technology may be used in science classrooms to encourage the use of dialogic processes between students and their teachers – a very important component of IBST. Wenche Erlien from the Norwegian Center for Science Education will contribute to this talk by introducing us to Naturfag.no and to Viten.no as resources for science teachers.

Seeing the natural world: a tension between pupils’ diverse conceptions as revealed by their visual representations and monolithic science lessons
Michael Reiss, Institute of Education, London

In this talk I report on drawings of the natural environment produced by a sample of 13-14 year-olds in work undertaken with Carolyn Boulter and Sue Dale Tunnicliffe at the Institute of Education, University of London and funded by the ESRC. One of our interests is in the extent to which these young people see the world in the way rewarded in science lessons. With rare exceptions, school science generally assumes that for any scientific issue there is a single valid scientific conception so that alternative conceptions are misconceptions. However, the drawings reveal a plurality of ways in which the natural environment is portrayed and we conclude that there is scientific as well as other worth in this diversity. We argue that schools need to take account of this diversity; many pupils will not be interested in a single, monolithic depiction of the natural world in their school science lessons.
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Full papers: Planning science instruction

December 2008
Planning science instruction

Teacher educator and student teacher conceptions of teaching and learning
Lena Renström

Students’ understanding of photosynthesis
Hrefnía Sigurjónsdóttir and Hálldóra Lóa Porvaldsdóttir

The influence of the teaching material used in class on children’s ideas about the human body
Gunnhildur Oskarsdóttir

Naturfaglæreren i møtet med eleven som IKT-bruker
Anne Bonnevie Lund, Jardar Cyvin and George Sundt.

Writing for science and science textbooks: a case study from Iceland
Allyson Macdonald, Audur Palsdottir and Helgi Grímsson

Creating brochures: an authentic writing task for representing understanding in middle school science
Christine Tippett, Larry Yore and Robert Anthony

The importance of science lab work
Olle Eskilsson and Gustav Helldén

Student study orientations and responses to teacher regulating approaches in science
Are Tumbo and Eyvind Elstad

University students’ personal ideas about school physics as starting point for dialogic/interactive talk
Margareta Enhag

Moving into the Zone of Feasible Innovation
Audur Palsdottir and Allyson Macdonald
Teacher educator and student teacher conceptions of teaching and learning
Lena Renström lena.renstrom@umn.su.se

Abstract
In this study five teacher educators and eight student teachers were interviewed about how they experience one of the objectives in the curriculum for teacher education in Sweden. The objective concerns teaching and learning. This study has its base in the phenomenographic approach. The contextual analysis of the transcripts reveals six conceptions of teaching and learning which are characterized in six categories of descriptions. Relations between the aspects of the conceptions, the architecture of the variation, are described in a system which has the form of a staircase and is labeled ‘The Staircase of Teaching’. The staircase of teaching shows how the qualitatively different conceptions of teaching increase in complexity and how new aspects of each conception colour all the aspects of the previous conception. In this paper the focus will be on how the aspect learning is experienced in the conceptions. The outcome space of the six categories of description shows how teacher educators and student teachers experience the objective in terms of teaching and learning. The result of the study might have important implications for teacher education in; writing course curriculums, students’ assignments, criteria for grades, assessment, and evaluating reports.

Introduction
In 1994 the Swedish compulsory school got a new curriculum (Lpo 1994). Three years later the curriculum had already been revised (SOU 1997:21). In the revised version we see a direction towards a social cultural view of learning. According to the government the process of the implementation of the new version of the curriculum was too slow. In order to support the implementation a reform for the teacher education was introduced (SOU 1999:63).

The implementation of the reform of the teacher education at the Stockholm Institute of Education was evaluated by Hörnqvist (2004). In order to evaluate if the intended reforms had been implemented, Hörnqvist looked for connections and progression between courses in the curricula of the teacher education programme. According to her the objectives of the courses were too abstract to give directions in line with the reform. Hörnqvist also questioned if any consensus existed concerning the concepts used and wanted to see a more explicit curriculum in order to make it possible to evaluate and to reach unanimous interpretations. If there was no consensus concerning the meaning of concepts such as teaching, learning, subject and knowledge, in the objectives in the curriculum, it would be difficult to plan for a progression in and between the courses. Hörnqvist highlights critical aspects concerning the progression and quality in the teacher education. If it is not possible to see and follow the intentions of the reform through studying the curriculum, we have to ask how they are interpreted by those who teach and study the courses. In order to work towards an improvement it is necessary to find out how these concepts are experienced by teacher educators and student teachers.

The aim of this study is to search for and describe how teacher educators and student teachers experience teaching and learning.

A phenomenographic approach
The phenomenographic research approach was developed at the Department of Education at Gothenburg University almost thirty years ago (Marton, Dahlgren, Svensson & Säljö, 1977). Since that time, the research approach has developed into a learning theory named the theory of variation (Runesson, 1999). The focus of the research is to look for and describe the qualitatively different ways individuals conceptualize or experience certain phenomena (Marton & Booth, 1997). The phenomenographic approach is therefore used in this study.

According to the phenomenographic approach, it is not possible for an individual to create his/her own ways of experiencing a phenomenon. In a social and physical surrounding there are only a limited number of ways of experiencing phenomena. In this study the social surrounding is the same for all participants since all involved are teacher educators or teacher students. In phenomenography, some ways of experiencing a phenomenon are seen as more complex, powerful and advanced than others. A complex way of experiencing consists of more aspects and concepts, than a simpler one. That means that in every situation concerning teaching it will be possible to search for and discern certain aspects of the phenomena. These aspects have to be caught and related to each other in categories of description (Emanuelsson, 2001; Neuman, 1987; Renström, 1988; Renström, Andersson & Marton, 1990; Runesson, 1999).

Method
Five teacher educators and eight student teachers were interviewed in the autumn 2004. The interviews started with a short discussion around the new curriculum for the teacher education before focusing on the objective of teaching. The objective was:

- to transform good and relevant knowledge in subjects and subject areas so that all students will learn and develop (Utbildningsplan, n.d.)
The interviews were transcribed and analyzed using a contextual analysis (Svensson, 1989). First, the interview excerpts were analyzed in order to discern and delimit the externally different characteristic ways of experiencing teaching, the conceptions. The second part of the analysis started when it was possible to discern and delimit the internal attributes, the emphasized aspects of the experience. It was in this latter analysis that the architecture of the variation of aspects appears and a more complete and genuine description is captured. A contextual analysis always has a movement in what is revealed and the analysis can therefore be considered never-ending. However, the movement in the description will slow down or become consolidated.

Six ways of experiencing teaching and learning
The result of the study is a description of the variation which consists of six qualitatively different conceptions or ways of experiencing teaching and learning. In a phenomenographic study it is not of interest to follow and describe what one individual is expressing. Rather, the conception emancipates from the expressed what is expressed by the collective of participants during the interviews. Teacher educators and a student teachers can, as we see in the excerpts, express different conceptions depending on what is discussed. However, teacher educators seem to express more complex conceptions than student teachers.

Categories of description
Teaching always concerns a subject and therefore the categories of conceptions are named after how the aspect subject is experienced. The six conceptions are:

I. The subject taught in school
In order to discern and identify a subject it has to be related to another subject or to be related to the place where the subject is taught. An example is: “Do you mean physics at the university or at the teachers’ institute?” This experience will appear early in a conversation in order to reach a consensus.

Didactics is a new subject for the student teacher Jim. Jim tries to avoid explaining what the subject didactics is with a taken-for-granted-expression before he elucidates the “subject” with the help of naming the “school” where didactics is taught. Notice that no other characteristics are mentioned in order to describe “didactics”.

Jim: That means then …yes, maybe I don’t have to tell what it means …Everyone will understand that …
I: Yes …I’m not so sure …
Jim: No, OK …That is …This is how it is. We have one lesson every second week – one day every second week at the teachers’ college …It is hard all the time to move from this very broad perspective as it means to be at the university and then down at school level and then up and down,

II. Subject-teacher is an entity
In this conception we see two aspects, subject and teacher. The teacher is often expected to be very knowledgeable in the subject. Here the lecturing teacher naturally will be emphasised, praised and defended. There is no sign of thinking concerning students.

The student teacher Jim appreciates lectures and expresses an aversion for seminars which is the most common form of teaching at the teachers’ college. In the following excerpt we see an expression of how learning can be experienced in this conception

Jim: Yeah, it’s like I said …It’s a one-way-communication … to say it bluntly …
I: You say one-way-communication … If I understand you correctly … from …
Jim: Yes …Well, it’s like swearing in the church …but …yes really …that’s exactly what I experience at the university just now …lecture.

A student teacher knows of course what a “student” is. However, we see that Jim in the next excerpt sees himself as a “student”. In this experience of teaching there is no space for “students”.

Jim: No, no …I’m totally busy with being a student myself just now …It’s like being a teenager, thinking: When you will become a dad, when you will become a dad …I’m totally busy growing up, and now I’m totally busy with these subjects.
In the next conception we see how the new aspect, the student, will "colour" the two aspects in that category and constitute a new conception.

**III: The subject is transferred to the student**

The three aspects, subject, teacher and student, seem to constitute a well delimited and stable ground for this conception. When the teacher transforms and simplifies the subject a "ceiling" for the subject taught will appear. In the process of transforming, the subject seems to become narrower. The teacher chooses, explains and simplifies the concepts so that the student will have tools to work with. The conception of learning concerns the process of transfer from the teacher to the student.

Only in this conception is learning seen as a transfer of knowledge. The student teacher Mike makes use of the English language to express the Swedish word for learning.

Mike: Learning [lära], that is … that is two … two … two meanings so to say … Yes, it is … for in English they have two words for learning, teach and learn, and that's what it really is about … Just now in this course, I have the feeling, they focus on the teacher … and how the teacher should teach [lära ut]

If the teacher finds the subject too hard for the students to learn or understand it is common that the students will have to imitate or repeat the content or learn the content by heart.

**IV: The subject is exposed to the student**

The new aspect in this conception is "learning" and the concept has a base in scientific learning theories. Learning will be possible if the learner is active. The learner creates her/his own knowledge. The role of the teacher is to expose the content in a rich and stimulating way in order to promote and support learning. The learner is "active" in the learning process by testing, experiencing, discovering or investigating. The activity leads to engagement, learning and understanding. The teacher is aware that students learn in different ways and the concept "learning styles" is often used. It is hard for the teacher to control what is learned.

The student teacher Mike relates learning to the use of different methods of teaching.

Mike: Yes, learning … I … to me it's like working methods
I: Like working methods? … Can you give an example so I understand what you mean?
Mike: Working methods … well, to me working methods are … have several different alternatives then, so to say … // you can for instance … if you are allowed to say so … drop a problem bomb and let the group of students work with it, like that, or that you have some kind of practical working methods … // Different ways for them to learn, well, you can also be so down to earth so that … you will say stuff … so that it will be different ways to learn.

Several ways to expose the subject will lead to learning. In the excerpt Mike emphasizes several alternative methods more or less as a "guarantee" to promote learning.

**V: Student prior knowledge is related to the concept structure of the subject**

The subject is now described with concepts and how they can be developed in concept structures or concept maps. It is important for a teacher to know about these structures in order to be able to relate student prior knowledge to them. Learning is expressed in terms of concepts related to the actual goal of the teaching. Student prior knowledge will be evaluated in relation to the structure of the subject. What is "right or wrong" will then be obvious. It is common to see student experiences as misconceptions.

The teacher Lars emphasizes how important it is for him to know about didactics so that he will be able to ask the right questions in order to reach the goal of the lesson. He maps student prior knowledge by getting students to explain the topic. The "right answer" is the objective.

Lars: Well … explanations, then you know some … that they have … When you explain something you show that you can use them, the concepts you have … then it's, of course, the right answer which is what you want.

When Lars describes a "good" learning situation, he mentions that he knows the subject but lacks knowledge about student prior knowledge. In order to be able to plan and organize "good" situations for learning, he needs to know more about student thinking. This dualistic view between the subject and student thinking is gone in the next conception.

**VI: The subject is seen as a human construction**

The subject is now seen as a human construction and is expected to be taught as such. The subject is expressed as accepted thoughts, principles, rules or laws, which can be questioned and developed. Together the teacher and the students constitute the subject.
The basis for teaching is the students’ thoughts. There are no “rights” or “wrongs” in student knowledge. The teacher will try to find an embryo in what the student expresses in order to make it visible and a basis for discussion. The students have to argue based on their experiences, listen to other students, discuss and evaluate them in order to find the most relevant meaning at the moment. The teacher elucidates and communicates his/her view of learning with the students and expects the students to be aware of their learning through sharing views in conversations and through documentation.

In the following excerpt the teacher Carl expresses the “subject” as being something you think. The expression “accepted models” for the “subject” is a sign of a subject which is not static or existing. It is also a sign of a non-dualistic relation between subject and thought.

Carl: … That you know about accepted models so that you understand them, that you have a conception about … not only that you have a mathematical model but also that you have a certain model or a picture of your own which can give metaphors … // It’s not possible for me to have a lecture and assignments and things for 30 different students, so … what it is about is … that I consciously move the responsibility so that they will be active, so that they will do it in different ways but will come to the same conclusions.

The experience of the concept development in this conception differs from the previous where the teacher worked towards the right answer. In this conception the teacher tries to develop or change student conceptions through argumentation so the student might see his/her conception in relation to others. Through a variation will the learning object be visible.

Carl says that he acts differently with different types of “concepts”, depending on whether he is dealing with facts or concepts which can have different meanings. What is a concept? The following excerpt will show an example of how it can be experienced.

Carl: … context? … I believe … but… what is it? … and I think that is really good … that you aren’t … quite sure … I think that you should… always be a little uncertain…

There is no right answer to what a concept is. Instead Carl believes that it is good not to be sure or a little uncertain about what it is. What he expresses is a description of the nature of learning in this conception. Uncertainty seems to be a driving force in learning.

Discussion
According to Husserl (1973) you can never reach the complete conception through studying “the general” in “separate excerpts” since the conception as such is a concept. The result of his study cannot be a ultimate description of the concept of teaching. However, it is one description of how teaching and learning can be experienced. It will certainly increase our possibilities to reach consensus, to embody objectives for courses and to evaluate the ability to teach which student teachers are expected to develop. The six conceptions show a hierarchy of increased complexity. A new concept constitutes a new and a more developed model for discussion and explanation of teaching. An aspect from the previous conception will be explained in a new and more complex way. That means that the aspects subject and learning will have a progressive and more complex description from conception II: (Subject-teacher is an entity) to conception VI: (The subject is seen as a human construction).
The staircase of teaching – the architecture of the conceptions

The architecture of the variation of the involved concepts is described in the *staircase of teaching* (Table 1). The qualitatively different conceptions are presented vertically and the aspects horizontally. A new aspect is marked with cursive script in order to emphasize that this aspect will “colour” all the aspects in the previous conception.

Table 1  The staircase of teaching – the architecture of the conceptions

<table>
<thead>
<tr>
<th>Conception:</th>
<th>Experience of:</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
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<td></td>
<td></td>
<td>The subject taught in school</td>
<td>Subject-teacher is an entity</td>
<td>The subject is transferred to the student</td>
<td>The subject is exposed to the student</td>
<td>Student prior knowledge is related to the concept structure of the subject</td>
<td>The subject is seen as a human construction</td>
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<tr>
<td>Nondualistic relation content and thought</td>
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<td>There is no subject as such, only as it is experienced</td>
</tr>
<tr>
<td>Concepts/Conceptual Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mapping of student’s prior knowledge (teachers’ perspective, misconceptions) Description of students’ conceptual development (students’ perspective)</td>
</tr>
<tr>
<td>Learning</td>
<td></td>
<td>The student actively creates her own knowledge (learning style)</td>
<td>The student constructs concepts according to subject’s development</td>
<td>The student constitutes concepts and thereby the subject</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student role</td>
<td>Student listens, receives, repeats and “learns”</td>
<td>Student investigates, experiences and discovers</td>
<td>Student’s prior knowledge is revealed in various ways</td>
<td>Student documents and argues thoughts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher role</td>
<td>To lecture and demonstrate</td>
<td>To clarify, simplify, convey, assist and “teach”</td>
<td>To provide well chosen situations to enable learning</td>
<td>To search for student’s prior knowledge and work towards set objectives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The subject</td>
<td>The subject taught in school</td>
<td>Subject-teacher is an entity</td>
<td>The subject is transferred to the student</td>
<td>The subject is exposed to the student</td>
<td>Student prior knowledge is related to the concept structure of the subject</td>
<td>The subject is seen as a human construction</td>
<td></td>
</tr>
</tbody>
</table>
The staircase of teaching – a tool for learning and reflection

How student science teachers develop their teaching and the role of the teacher has been followed in a longitudinal study (Lager-Nyqvist, 2003). The results show that teacher education had not been successful in changing student teachers’ ability to interpret and realize the didactic goals in their profession. It is remarkable that Lager-Nyqvist found that the student teachers, after two years of working as teachers, taught their own pupils in the same way as their own science teachers once did. In order to be able to reflect and change the view of teaching you might need to be aware of different ways of how teaching can be experienced. You might have to see a variation of conceptions in order to learn.

Neither in the curriculum for teacher education (Högskoleförordningen, 2001:23) nor in the curriculum for the compulsory school (Lpo, 94), one way to interpret the concept learning is expressed. It is possible therefore that the objectives can be interpreted in five qualitatively different ways. In order to reach a consensus it is essential to elucidate and identify actual ways of experiencing the concepts. The staircase of teaching can be the tool needed for reflection and learning about teaching. The staircase of teaching shows a progression and can therefore also be used for evaluating objectives, plans, assignments and teaching. If a reform is to be successful, it may be especially important to have methods that can be used to describe, clarify and evaluate the intended change.

The staircase of teaching provides a platform for further reflecting discussions which can lead to new experiences and development of teaching.

References
Students´ understanding of photosynthesis
A study in three small rural schools in Iceland
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Halldóra Lóa Thorvaldsdóttir

Abstract: In this study the objective was to study how well young pupils understand the process of photosynthesis. The results are discussed in light of constructivism and compared to similar studies from other countries. No comparable study has been carried out previously in Iceland. In total 94 pupils from 3 rural schools answered ten questions on the subject. The students were 10 years old (N = 38) and 15 years old (N = 56). The older group was also asked to explain four points further in writing. The results suggest that the knowledge and understanding of the pupils is poor and the objectives given in the Icelandic curriculum are far from being achieved. The older students had difficulties in explaining the processes of photosynthesis and the relevant concepts. Also, their answers in their open questions suggested that their choices of answers in the multiple choices questions were sometimes coincidental. The conclusion is that Icelandic pupils do seem to have the same misconceptions about photosynthesis as learners in other countries and that their learning in this field is often limited.

Background, aims and framework
In Iceland little research has been carried out on student understanding of basic scientific concepts. Here we present data from a study that is based on the second author’s B. Ed. project from 2006. The aim was to get some insight into pupil understanding of photosynthesis in Iceland.

Photosynthesis is one of the most fundamental concepts in biology and is traditionally taught in more than one subject within biology (cell biology, plant physiology, ecology, botany). The process of photosynthesis is indeed complicated and knowledge in chemistry and physics is essential to acquire a full understanding of all the processes which happen within the cell. Such detailed knowledge is usually only achieved in subject courses at tertiary level. Most teachers in compulsory schools in Iceland do not have such a background. The question is: How can we expect teachers with a limited background in science to teach this difficult field to students? As we know from earlier research, misconceptions about photosynthesis are very common among students of all levels (Bell, 1985; Driver, Guesne & Tiberghien, 1985; Driver, Squires, Rushworth & Wood-Robinson, 2003; Eisen & Stavy, 1988; Yenilmez & Tekkaya, 2006).

For these reasons it would be no surprise if young pupils in our schools have a limited knowledge and understanding of photosynthesis and this is what we expected to find in this study.

According to the National Curriculum in Iceland from 1999, 10 year old children are expected to:
• explain what components are essential for photosynthesis to happen,
• explain what the products from photosynthesis are, and
• explain what role photosynthesis has for the world’s ecosystems (Ministry of Education, Science and Culture, 1999, p. 49).

At age 14- 15 students are expected to be able to:
• describe the energy needs of organisms and how they get their energy,
• explain cellular respiration and photosynthesis and how the relevant chemical processes connect,
• describe the specialization of chloroplast and mitochondria, and
• know which organisms can carry out photosynthesis (Ministry of Education, Science and Culture, 1999 p. 69).

Textbooks and other teaching material are available for teachers to cover the relevant topics. However, teacher guides do not especially address the most common misconceptions and the text is probably too complex for teachers with limited scientific background.

Methods and samples
In total 94 students from three small rural schools in the west of Iceland answered ten questions on photosynthesis in a multiple choice test (they were asked to mark the best answer). Most of the students in the three schools answered the questions. The pupils were in the 5th grade (age 10, N = 38) and in the 9th grade (age 15, N = 56). We carefully designed the questionnaire with respect to what the teachers had emphasized and other studies with which we could compare our results. The questions and responses can be found in Table 1.

The 15 year olds were also asked to answer four questions in writing where they were supposed to explain their answers.
Table 1  Results of multiple choice test about photosynthesis.

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>% right answer</th>
<th>Most common wrong answer (% and option)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5th grade</td>
<td>9th grade</td>
</tr>
<tr>
<td>1</td>
<td>What are the outcomes of photosynthesis?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. CO₂ changes into O₂</td>
<td>21</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>ii. the plant can breathe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. the plant can make nourishment from inorganic matter</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. plants can get rid of waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Through which body part does the plant incorporate CO₂?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. through the roots</td>
<td>33</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>ii. through the leaves</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. through the stems</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. it does not take up CO₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>The food stuff of plants is made of:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. water and soil</td>
<td>56</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>ii. CO₂ and soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. glucose</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. water, CO₂, minerals and the energy of the sun</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Plants need light:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. to produce nourishment</td>
<td>62</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>ii. to reproduce</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. so that insects can see them</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. so that water can evaporate and thus become available for photosynthesis</td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td>Plants:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. need constant light so they can get nourishment</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>ii. do not need continuous light so they can get nourishment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. are not dependent on light to get nourishment</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>iv. need more light in some seasons</td>
<td></td>
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<tr>
<td>6</td>
<td>The chloroplast:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. has the important role to make the leaves green and attract insects</td>
<td>67</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>ii. has the important role to harness the sun’s energy to produce nourishment</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>iii. reflects the green waves of the light</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. has no important role</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>Water is</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. a necessary component in photosynthesis</td>
<td>51</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>ii. an important molecule but not in photosynthesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. rather necessary but not essential for plants</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>iv. only necessary for animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Which of the following statement is not correct? Photosynthesis occurs in:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. flowers and trees</td>
<td>37</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>ii. plants and some protista</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. plants and algae</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. only plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Oxygen flows into the atmosphere when:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. plants breathe</td>
<td>11</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>ii. animals breathe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. plants deliver waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. when organic molecules rot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Do algae photosynthesize?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. yes</td>
<td>49</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>ii. no</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. only when they need to</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv. no, they get food like animals</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The four questions that the ninth graders answered in their own words were:

1. What use do the plants have for light?
2. What role does the chloroplast have?
3. What is the difference between glucose and starch?
4. Why do plants need food stuff/nourishment?

Results
In Table 1 the proportion of pupils that scored right in the multiple choice test is given for each class and also what the most common wrong answer was.

The results are remarkably similar for the two age groups. Pupil misconceptions seem to prevail in spite of additional teaching and more detailed explanations in the textbooks. What many of the older pupils have though clearly learned is where the uptake of CO$_2$ takes place (it is covered in the teaching material for the 8th class), and that oxygen is the byproduct of photosynthesis. The misconception that photosynthesis is the process where CO$_2$ is changed into oxygen is very strong (Question 1). Also, the misconception that respiration in plants produces oxygen is very common for both age groups (see Question 9).

The results from the open ended questions showed that the majority of the 9th class pupils were confused and their answers were generally ambiguous and limited in scope. The open answers tell us more about the students that have not learned much in this field, and their misconceptions, than the group's true understanding. Thus, 20% say in the open-ended questions that they do not know why light is important for plants but only 55% actually chose the right answer in the questionnaire. 35% do not know what role the chloroplast has, 80% do not know the difference between glucose and starch and 17% do not know why plants need nourishment to live.

Conclusions and implications
The results show that majority of pupils in the sample have a poor understanding of the concept and processes of photosynthesis. Only 40% of 15 year old students and 20% of 10 year old students know that through photosynthesis organic matter is produced from inorganic molecules and energy from light. The process of photosynthesis is not well understood and the majority believes that the purpose is to change CO$_2$ into oxygen. Also, the 9th graders did not do much better than the 5th graders although students have lessons in cell biology including cellular respiration and photosynthesis in grades 6-8. Our results show that 15 year old students do not seem to realize that plants also need nourishment, (a source of energy) to function and that the same law applies to them as animals regarding respiration. Similar findings have been reported from other studies (Bell, 1985; Driver, Squires, Rushworth & Wood-Robinson, 2003; Yenilmez & Tekkaya, 2006).

The fact that the misconceptions among 10 year olds are also common in the 9th grade tells us that the teachers have probably not taken pupil initial conceptions into account. Our advice to teachers is that they should reflect on their own understanding and improve their knowledge if needed. Also, they should map their students’ initial conceptions through both questionnaires and discussion. On the basis of this they could design teaching in such a way that pupils gain more depth in their understanding of natural phenomena. Thus further learning can become more meaningful as Ausubel (1968) discussed a long time ago.

References
Planning science instruction

The influence of the teaching materials used in class on children’s ideas about the human body
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Abstract: The paper explores what kinds of ideas children in the first year of primary school have about the human body before being taught about the subject, how these ideas change and develop during the teaching and what factors especially influence the change in the children’s ideas. Special attention will be paid to the influence the teaching material used has on the ideas the children have about the human body. One primary school class of 19 children in Primary one was chosen to take part in the research along with its teacher. The research lasted for two school years (Primary one and two). The methodology involved classroom observation and individual interviews with the children. The children made drawings from the beginning of the project and right to the end. All the drawings were collected and analysed. At the very end of the project the children completed a few diagnostic tasks to get information from as many sources as possible. Using drawings to get access to children’s ideas can be very effective although young children may have difficulties in making drawings that represent their ideas, although the imitation effect has to be taken into account as drawings can present imitation rather than understanding. The research gives important information about children’s ideas about the body and how they change. It shows that teaching material and especially pictures in textbooks and tools and models e.g. the visual things can have great influence on children’s ideas. The results show that the drawings in the textbooks used have a substantial effect on the children’s ideas as the children tended to imitate the pictures in the book when they were asked to show their ideas in drawings, although the drawings did not always represent their ideas as revealed in the interviews and diagnostic tasks.

Background, aims and framework
The understanding and the development of children ideas about scientific issues has been the focus of a many studies (Driver, Guesne & Tiberghien, 1985; Driver, Squires, Rushworth & Wood-Robinson, 1994; Helldén, 1999; Lawson, 1988). A number of studies have been done on children’s ideas about the human body. Gellert (1962) made a study of the ideas that hospitalised children aged 4-16 had about the human body. The dominant answers in Gellert’s study to the question of what is inside people were similar to the results of the British SPACE study which showed that the children in the study were operating with a knowledge based on simple broad mechanisms like, ‘you need food to keep you alive’ and ‘blood keeps you alive’ (Osborne, Wadsworth & Black, 1992). The study showed that children draw the organs that are more easily sensed, like the heart which beats and the bones which they can feel. Carey (1985) reviewed a number of studies on children’s ideas about the body. According to her it is not until the age of 10 that children appear to understand that the body contains a number of organs which function together so we can live. Reiss and Tunnicliffe have undertaken extensive research on children’s ideas and understanding about the body where they have used a variety of approaches, including drawings, to establish children’s ideas about the structure and location of the different organs of the human body (Reiss & Tunnicliffe, 1999, 2001; Tunnicliffe & Reiss, 1999; Reiss, Tunnicliffe et al., 2002).

When children come to school they have experienced various things and bring with them their ideas and interpretations concerning certain concepts or phenomena and children form their ideas and interpretations on the basis of everyday life and experience (Driver, Guesne & Tiberghien, 1985). According to Farmery (2002), children build up ‘scientific’ knowledge from a range of sources outside the school environment:

… knowledge that may be very different from that which we would wish them to develop. These different understandings are often referred to as pupils’ misconceptions (p. 103).

Some misconceptions are quite common and may be very resistant to change. It is therefore important for the teacher to be aware of them and be able to respond appropriately when they occur (Farmery, 2002). Educational experiences can lead to misconceptions or maintain misconceptions. Clément (2003) talks about didactical obstacles to learning that come from contradictions between previous teaching and scientific knowledge and suggests that primary school textbooks can, by making things simple, maintain misconceptions. According to him many of the earlier French primary school textbooks often draw “the way of the food” from mouth to anus, with precise times: a boy is eating an apple at...
In this paper a special focus will be on the influence of the teaching materials used in class.

**Methods and sample**

One class of 19 Primary One children and their teacher were chosen to take part in the research which continued in Primary Two. The research tradition used in the study can be described as ‘eclectic’ since a number of research methods were used in order to get information from different perspectives to increase the validity of the conclusions (Bogdan & Biklen, 2003). These methods were classroom observations, interviews, drawings and diagnostic tasks. The children were asked to draw pictures at every stage of the study right from the beginning, before teaching about the body started and then continue to look at and understand bone units such as leg bones or ribs (Reiss & Tunnicliffe, 1999).

The children were especially influenced by the figure of the digestive process in the school textbook (Carvalho et al., 2004). After teaching about digestion the great majority of children reproduced the textbook schema in their own drawings. They did not show the continuity of the digestive tract and showed confusion in the anatomy and connections of the small and large intestine. None of the 120 pupils in the study drew the passage of digested products into the blood. Twenty three per cent of year 3 pupils, however, mentioned ‘blood absorption’ when asked to write a short text about the digestion of a cookie, although they did not show it in their drawings. However, the researchers think these comments were made after learning by heart rather than from understanding, as most of the primary school textbooks mention ‘blood absorption’ without an explanation of what this means.

Another important issue in the discussion of teaching about the body is the use of metaphors and analogies when teachers are explaining scientific issues (Ogborn, Kress, Martins & McGillicuddy, 1996). Children’s use of metaphorical thinking is discussed by Holgersson (2003). According to Holgersson, children use metaphors when trying to explain different scientific phenomena, and to make their explanations more understandable. Reiss and Tunnicliffe believe that children learn about the body as units which they gradually piece together (Tunnicliffe & Reiss, 1999). When learning, for example, about the skeleton, children start with bones in general, then progress to bones in particular places and then continue to understand bone units such as leg bones or ribs (Reiss & Tunnicliffe, 1999).

Reiss et al. (2002) suggest that science education builds upon and extends the knowledge that children bring to science classes and, as with the bones, it seems that children learn first that they have certain individual organs. Then they realise that these organs are situated in a special location and then they come to realise that some organs function together and are connected in functional units (e.g. the oesophagus is joined to the stomach). In some cases children then learn that a number of organs function together in a whole organ system. Therefore teaching about the body should start by teaching or exploring individual organs and then helping children to learn that they function together and are connected in functional units (e.g. the oesophagus is joined to the stomach). In some cases children then learn that a number of organs function together in a whole organ system. Therefore teaching about the body should start by teaching or exploring individual organs and then helping children to learn that they function together and they all are a part of the same functional system (Reiss et al., 2002).

These studies give an emerging picture of the understanding young children have about the human body and some of them also address possible obstacles to learning and the influence textbooks can have on children ideas. To look further into the main effect on the change in children’s ideas the following research questions were put forward in the study presented here:

- How do the ideas that Icelandic children bring to primary school change over the course of the first two school years during teaching about the human body in relation to location and structure (bones, muscles, heart, lungs, brain, digestive-system), function (of the heart, skeleton, lungs, brain, stomach) and processes (digestion and blood circulation)?
- How are changes in pupil ideas affected by the curriculum, teaching methods, teaching materials, teacher-pupil and peer interactions, or other factors?

In this paper a special focus will be on the influence of the teaching materials used in class.
and understanding of how certain words and concepts were used and understood (Banister & Parker, 1994; Lofland & Lofland, 1995). A special form was also developed to analyse the drawings, the interviews with the children and the diagnostic tasks.

Results

The teaching material used when teaching about the human body is *Komdu og skoðaðu líkamann/Let’s look at the body* (Óskarsdóttir & Hermannsdóttir, 2001a). This material consists of two books, a large book (“the Big book”) used to display pictures to the whole class with additional text for the teacher and a smaller textbook for the children with the same pictures but a much simpler text. The materials were supplemented by an extensive web-site where teachers can find teaching guidelines and other materials including different activities to try out with the class. It also has a 'storyline frame' about the human body, interactive tasks on the computer for the children to work on individually or in pairs or small groups, games and drama exercises and examples of formative assessment (see Óskarsdóttir and Hermannsdóttir, 2001b).

The teaching started by exploring the body as a whole. Thereafter the focus was mainly on individual content units, that is, the bones, the heart, the lungs and the circulation, the stomach and the digestive process, the brain and the senses and reproduction. The teacher used a wide range of teaching methods while teaching about the human body. Many of these aimed at gathering evidence about children ideas about the human body, others aimed at extending children ideas. The main teaching methods the teacher used were: short introduction (mini lectures), class discussion (questioning and discussing), practical work and investigations, interactive activities on the Internet, drama and demonstrations.

The results show that the various teaching methods have different effects for different children and thus a variety of teaching methods are important in order to maximise learning within a whole class. It is hard to conclude which teaching method is, overall, ‘the best one’ although a combination of group demonstrations, hands-on activities, information/telling and discussion were very effective.

The teaching material *Let’s look at the body* clearly had a great effect on children ideas, both books (the Big book and the textbook for the children) and the activities on the Internet. Working in pairs the children did a few interactive activities on the Internet which are part of the teaching material used (Óskarsdóttir & Hermannsdóttir, 2001b). In one of the computer activities the children were supposed to put the different organs, that is, the heart, lungs, stomach, kidneys and liver into the right place of the body. According to the drawings the children made after this lesson, these activities seemed to have influenced their ideas. Some drew the organs inside the body after this activity; four of the children drew the kidneys just somewhere inside a drawing of a body, even though they could not remember the name of the organ or exactly where the kidneys were supposed to be. They just remembered that this kind of organ was somewhere in the body. There are however also very detailed pictures of the kidneys in the books, which could have, along with the interactive tasks on the Internet, influenced the children who drew kidneys in their drawings of the organs in the body.

The teacher used the Big book when talking about and explaining certain issues and concepts and showed the big pictures to the whole class. The pictures in the books have a great effect on the children’s ideas according to the results as they tended to imitate the pictures in the book when they were asked to show their ideas in drawings. There are also words in the textbook used that obviously had an effect on their ideas. The teacher used the wording from the book to describe different issues, as when talking about the liver she described it as the *body’s cleaning machine*. She also said the muscles in the stomach worked like a *Kitchen-aid mixer*, and that the blood was a fluid that carried nutrition around the body like a *train*, with the white blood cells protecting us against illness like guard dogs, *woof, woof…* In the interviews the children who knew something about the liver used the same words and phrases, saying that the liver was some kind of a cleaning machine or had something to do with cleaning. One said: “The liver is the main cleaning factory of the body” and another said: “I cannot remember the name of it but it cleans something.” In the interviews many children mentioned that the food in the stomach got mixed because the stomach worked like a mixer: “The food mixes in the stomach, because the stomach is like a mixer.” According to the diagnostic tasks one child confused the white blood cells with “bacteria that fought like dogs” but also confused them with nerve cells where she wrote: “white blood cells” as an answer to the question: What are the cells called that bring messages to the brain? Another child also mixed the white blood cells with the nerve cells as the example below from one of the interviews shows:

**Researcher:** What is this (points at the brain)?
**Child:** The brain so you can think, it also controls.
**Researcher:** How does it control?
**Child:** I don’t know.
**Researcher:** Do you know what the cells are called that send messages to the brain?
**Child:** Yes, the white blood cells.
**Researcher:** No, they are called nerve cells, but what do the white blood cells do?
**Child:** They send bacteria away.
**Researcher:** Very good but what about the red blood cells?
**Child:** They come from the heart.
The results indicate that the effect of the drawings in the textbook (Óskarsdóttir & Hermannsdóttir, 2001a) should not be undervalued as they seem to have more effect than expected as the children imitated the drawings in the book even though they did not always represent their ideas. They also sometimes had difficulties in making the drawings fit their ideas. The picture of a big egg (the Mother cell) seems to confuse some of the children, because the egg in the picture is so like a hen’s egg, even though it is round (see Figure 1).

Some children also think that the baby grows inside the egg or that the egg will change into a child as these examples show: “The egg becomes a child”. “No, first it changes into a cell and then into an egg”, “Yes, and then the child comes out and grows up”. After looking closely at the picture in the book one child said: “The egg opens up and if two (sperm-cells) can come in there will be twins”; then another said: “No, the cell comes from the egg” and yet another, “No, the cell is inside the egg until the cell turns into a baby”. The teacher told the children how the sperms (on the picture, see Figure 1) were trying to get into the egg and if one succeeded there would be a baby. She also told them about cell division and that the body was made of different types of cells that all came from the egg cell and the sperm. After explanations from the teacher, the children tried to make sense of this information but had difficulties with the idea of eggs and cells. It is as if they imagine the egg cell like a hen’s egg inside the mother and find this difficult to fit with their ideas.

The pictures explaining how the muscles work show the muscles just in the upper arm which could be one of the reasons why the children drew the muscles just in the upper arms and the thighs (Figure 2).

There is a picture in the Big book that is supposed to illustrate the circulation system (Figure 3).
The picture shows the heart shaped like a ‘Valentine’s heart’ and red and blue blood vessels around the body. However, the red part of the heart is to the right with red blood vessels dominating the right part of the body, but blue veins dominating the left part of the body. This picture also seems to have considerable effect on many of the children. Even though the teacher has shown them a model of a real heart and talked about the heart, saying that it does not look like a Valentine’s heart, they still drew it like the heart in the picture in the book, half blue and half red; and five of them still drew it like a Valentine’s heart even though they knew the heart was not exactly like that. When asked to colour the blood vessels red and blue many of the children started by drawing blue veins in the left side of the body and red blood vessels in the right side of the body as in the picture in the book. They changed it, however, when the teacher corrected them.

One picture in the book concerning the digestion system shows the mouth full of food in whole pieces, like a whole apple, or whole carrot, or a whole slice of bread with cheese (Figure 4).

When the children were asked to draw the food in their stomach before the teacher really taught them about the digestion system, most of them drew the food in their stomach in whole pieces as in the picture, even though they knew, according to classroom discussion, that you would choke if you swallowed the food in whole pieces.

There are two similar pictures of the brain in the Big book. Both show a side view of a grey brain with a brain-stem extending down from the brain. When the children drew the brain many of them drew it with the stem down from one side as they might have inferred from the illustration in the book (Figure 5).
The teacher also used the books, *The magic school bus. Inside the human body* (Cole, 1996) and *Svona erum við/That is how we are* (Kauffman, 1976) to emphasise her points and add to the discussion. She used *The Magic School Bus* when explaining the blood circulation and the way the food goes through the body when she put on little drama acts. She used *That is how we are*, when talking about the brain and showed them a detailed picture of the brain in the book and some of the children had that picture clearly in mind when drawing their own picture of the brain.

**Summary and discussion**

The books (Big book and the little textbook) and the teaching material used in this research had a greater effect than had been expected, so it is important to decide carefully what teaching materials are to be used, making sure that it matches the aims and objectives in focus.

Using drawings to get access to children’s ideas is very effective although it has to be borne in mind that some children have difficulties in making drawings that represent their ideas so drawings alone can be a vague research method if used alone. The imitation effect has also to be taken into account as the drawings can represent imitation rather than understanding.

The ideas the children in the study had about the body did not always reflect their knowledge and understanding as they tended to imitate the pictures in the textbook. Sometimes they seemed to use the drawings as symbols to illustrate their ideas and if there had not been other methods used to get access to their ideas we would not have a valid picture of their ideas, knowledge and understanding about the body. This is also a view expressed by Carvalho et al. (2004) but they claim that the drawings young children make to represent their ideas about digestion are more symbolic rather than realistic. The children in this study drew the food in whole pieces in the stomach even though they knew better; they drew the heart in two halves, red and blue, even though they knew the heart was not exactly like that; they drew the muscles in the upper arm as in the picture in the book shows and many of them drew the brain exactly like the drawing of the brain in the textbook. This was also the case in the study of Carvalho et al. (2004) where the great majority of children reproduced drawings from the school textbook about the digestive tract. Teachers have to be careful when analysing children's drawings and use other methods along with the drawings to enable them to get a clearer picture of the children's ideas.

It has been argued that metaphors and analogies play an important role in explaining scientific issues (Holgersson, 2003; Ogborn et al., 1996). In the textbook *Let's look at the body* certain words that children are familiar with are used to illustrate functions and processes such as ‘guard dogs’ for white blood cells and ‘a mixer’ for the stomach; the blood travels through the veins like ‘trains’ and the liver is the ‘cleaning factory.’ The teacher used these words or metaphors when explaining the organs and the functions and processes that they were involved in. These words or metaphors also seemed to have an effect as borne out in the interviews where some children remembered them and used them to illustrate their ideas. However, most of the children did not seem to understand what these words really stood for even though they remembered them and tried to use them, but I still think that they helped some of them to make connections. They also used metaphors like ‘the heart being a pump’. Adults use expressions in daily life when talking about the body, like: ‘the heart wants to be noticed’ when the heart is beating fast, ‘my head is about to burst’ and ‘my tummy is bursting’. These expressions are likely to influence children in using them as well and it does not mean that these will lead to and maintain misconceptions, but it has to be considered that this can have an effect on children ideas and explanations and if adults use terms and phrases like these why should children not do it? It is how we use the language and a part of our culture but it does not mean that we think or believe that our head or tummy will really burst.

**Conclusions and implications**

The results show that different teaching methods have different effects on different children. Thus a variety of methods are important in order to ensure a rich understanding and to take the ideas further. There is no single method for teaching and learning that fits all, so science education should consist of a wide variety of teaching methods, including telling and showing (demonstrations), taking into account that every individual learner is unique.

In the light of the results it is recommended that attention is paid to one issue at a time: bones and muscles, specific organs, how organs are connected and how they can be a part of an organ system, as recommended by Reiss and Tunnicliffe (2001).

The teacher should ensure that the environment is stimulating and encouraging. She should get books from the library and ask the children to bring books about the body to school, and make a display of pictures and models of the organs like the heart, the brain, and the skeleton.

The textbook and the teaching material used in this research had a greater effect than had been expected, indicating that it is important to decide carefully what teaching materials are to be used, making sure that they match the aims and objectives in focus.
The drawings young children make to represent their ideas about the body tend to be more symbolic than realistic and few examples support this view in the study. Therefore teachers have to be careful when analysing children's drawings and use other methods along with the drawings to enable them to get a clearer picture of the children's ideas.

References
Writing for science and science textbooks: a case study from Iceland

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Abstract: Science textbooks play an important part in school science in Iceland, as in many other countries. This research is one study in a larger science education research and development project currently being carried out in Iceland. This study is designed to gain an understanding of the way in which a science textbook developed for a specific context might influence the ‘science story’ being told to young learners. A revised national curriculum was published in Iceland in 1999. A series of three textbooks and teacher guides titled Auðvitað (Of course!) and written for the middle school, grades 5 to 7 (ages 10-12), are being analysed. The Auðvitað books, published in 2000 and 2001 by the National Centre for Educational Materials, cover topics in physical and earth sciences. The materials are used each year in several hundred classrooms involving about 4000 or more learners per age group. The books are analysed according to a scheme for textbook analysis developed in Greece by Dimopoulos, Koulaidis and Sklaveniti (2003, 2005). The study also draws on an analysis of books as ‘cultural objects’ according to a scheme developed in Spain by Izquierdo, Marzabal, Marquez and Gouvea (2007). Preliminary results indicate that the text in the chapters selected for analysis rests more on everyday knowledge than scientific knowledge. The text is presented in a relatively informal manner, given that it is from a science textbook, and the reader often has the responsibility of what to do with the main body of text being read. The overall message is that everybody can learn science! The visual images are generally realistic and the boundary line between what is everyday and what is scientific knowledge is blurred. Again the reader is left with the task of what to do with the image and the overall message to the learner is that science is not really amazing!

Aims and background

Science textbooks play an important part in school science in Iceland. In a small country resources must be used well and the science being taught in schools is of more than passing interest in a modern country which thrives on technology and change. Until 2007 the primary responsibility for the development of educational materials for compulsory schools in Iceland has been in the hands of the National Centre for Educational Materials (NCEM). In 2007 a new law on learning materials was passed (Act 71, March 28th 2007) creating an opening for commercially published material.

The purpose of this study is to analyse and understand the science ‘story’ told each year to middle school children in Iceland in books published by the NCEM. A series of textbooks and teacher guides called Auðvitað (e. Of course!) written for middle school grades 5 to 7 i.e. ages 10-12 are under investigation. The books cover topics in physics, chemistry and earth sciences and were published in 2001 and 2002 (Grímsson, 2001a, 2001b, 2001c, 2001d, 2002a, 2002b). The books are strongly aligned with the national curriculum from 1999.

This research is one study in a project called Intentions and reality being carried out in Iceland, with funding from the Research Fund of Iceland 2005-2007. This particular study also received funding from the Research Fund of the Iceland University of Education in 2007. The research question guiding the main study is: What is the nature of the gap between the intended curriculum and the actual curriculum – the intentions and the reality? Subsidiary questions include: What are the main features of the national curriculum in science in Iceland from 1999? What resources are available for science teaching and learning (particularly ICT) and what is their role? What learning and teaching practices are typically found in schools? What influences student choice with regard to science and technology in secondary, further and/or higher education?

In the 1970s there were several major curriculum projects underway in Iceland, including the production of new materials for science teaching (Macdonald, 1993a). In the late 1960s and early 1970s eight units in physics and chemistry, based on students carrying out experimental work, were written for learners aged 10-12. The units were short and in the form of worksheets with questions to be answered by students. Guidelines for using the materials were written for teachers and for a few years in the late 1970s inservice courses on using the materials were held around the country (Macdonald, 1993b). The use of scientific processes, such as measuring, observing and comparing, were encouraged in most of the units. All the units required preplanning with regard to apparatus and chemicals were required for two units. Over time use of the materials dwindled and by the late 1980s the most popular units were being used in less than 40% of rural schools and in 36% to 64% of urban schools (Macdonald, 1993c).

In 1987 an evaluation of the physical science middle school materials in 1987 was carried out on behalf of the Ministry of Education, Science and Culture (Macdonald, 1987a, 1987b). These materials were based on an experimental approach to science. In the mid-1990s the NCEM decided to produce new science materials for lower secondary school and by the late 1990s it was clear that teachers would need new materials in order to teach the revised curriculum of 1999. The task of producing a series of books for middle school physical and earth sciences was put out to tender. Earth sciences were a new area in the science curriculum and overlapped in part with the geography curriculum. The materials were to be developed in close cooperation between the NCEM editor responsible for science and the author. According to the NCEM and our own interviews the materials appear to have been well-received by many teachers and are used each year in several hundred classrooms involving about 4000 or more learners per age group.
Classroom observations in the schools in Iceland have shown that “teachers depend to an inordinate degree on the textbooks, for teaching methods as for content” (Sigurgeirsson, 1993, p. 274; Karlsson, 2007). This study contributes to an understanding of the textbook itself and the way in which a science textbook developed for a specific context might influence the ‘science story’ being told to young learners. The books are analysed according to a scheme (hereafter DKS scheme) for textbook analysis developed in Greece by Dimopoulos, Koulaidis and Sklaveniti (2003, 2005). It also draws on an analysis of books as ‘cultural objects’ according to a scheme (hereafter the IMMG scheme) developed in Spain by Izquierdo, Marzabal, Marquez and Gouvea (2007). A key part of the latter scheme involves what is called ‘communicability’ in which the books are analysed in terms of the model of science, the model of the reader and the didactical model being proposed in the textbooks.

This is a preliminary study on the role of the textbook in teaching and learning science. The intentions of the writers of the national curriculum have been recontextualised in the textbook in an activity which is guided by the intentions of the editor/publisher on the one hand and the writer on the other. What has happened in the recontextualisation (Bernstein 1996/2000)? What views of science, teaching and learning are present in society (Macdonald, 2007) and presented in the textbook? What influence might these views have on the use of the textbook by teachers?

**Frameworks for analysing textbooks**

In the United States, the National Science Foundation (n.d.) has developed frameworks for the review of instructional materials for middle school science. These pay particular attention to the quality of the science presented in books and the pedagogical design, and also consider the use of the materials and system support that might be required. Project 2061 which is run by the American Association for the Advance of Science (AAAS, 2002) has also drawn attention to the quality of science textbooks. Categories used in the AAAS scheme for the evaluation of texts include an assessment of the scientific ideas but emphasise the role of the learner by looking at whether account is taken of student ideas, whether students might become engaged with phenomena and how student thinking can be promoted. The use of the materials is also addressed through a consideration of the extent to which adopting the materials would enhance the science learning environment.

The above-mentioned schemes do not necessarily unpack the way in which the material is presented or the selection of content. There is an ongoing debate in the literature (Bennett, 2003) about the language used in science, whether contextual approaches influence the way science can be taught and what might increase student interest in science. We feel that the framework for linguistic and visual analysis of textbook materials developed by Dimopoulos, Koulaidis and Sklaveniti (2003, 2005) could help us understand the way science is being presented in schools. The pedagogic functions of the text and images are described through the concepts of classification and framing developed by Bernstein (1996/2000) and the notion of formality introduced by Halliday (1996, in Dimopoulos et al., 2003, 2005):

- **Classification**, which can be strong or weak, tells us something about the relationship between knowledge systems (Bernstein, 1996/2000). When it is strong, then each system has its own identity, but when it is weak then there are less specialised discourses. In this study we are interested in assessing the extent to which the science knowledge being presented in science textbooks is specialised or everyday.
- **Framing**, which can be strong or weak, tells us what regulates the communication between reader and text. In cases of strong framing the text is in a higher social position than the reader (Dimopoulos et al., 2005) and students have less access to the text than in cases of weak framing.
- **Low formality** (Halliday, 1996, in Dimopoulos et al., 2003, 2005) would reflect language that is more like colloquial speech or images that tend to the realistic. High formality arises from use of specialised scientific texts or formal representations (Dimopoulos et al., 2003).

In using the DKS scheme we are using *classification* to ask what sort of meanings of science are to be put together and *framing* to ask how the meanings are to be put together. The criteria used in analysing the material in the textbooks are shown later in the results section, for text analysis in Table 1 and for analysis of visual representations in Table 2.

The IMMG scheme developed by Izquierdo et al. (2007) in Spain considers not only the contents and concepts presented in books, but also the rhetoric (or story) being told. The Spanish researchers suggest that the ‘story’ is told not only through *factuality* and a consideration of how the facts are built into a book, but also through *communicability* which can be analysed by looking for indications of the model of science being presented, the model of the reader and the didactical model. An analysis of a text using this approach will tell us what sort of ‘science story’ is being presented in schools. This ‘story’ may or may not offer an approach with which teachers feel comfortable and which learners understand.

**Methods and samples**

Two chapters of the student book for 7th grade (20 pages) were selected for preliminary analysis using the DKS scheme. One was an introductory chapter on the nature of science and the other a chapter on properties of matter.
The basic layout is such that there is a written text (black and white) occupying about 65% of the width of a page and a side margin of about 35% (Figures 1 and 2). The text is broken up into sections of one or more paragraphs with short bold titles. Sometimes some of the text is given an additional label of being a ‘nugget’ of information. There are also short sections of text which are questions to the student labelled “Do you know the answer?” Visual images are found interspersed in the main text, in the margins or crossing both. The visual images consist of photographs, sketches and cartoons. Some visual images are extensively labelled, some only briefly and some not at all. Suggestions for simple experiments or problems for individuals or groups are marked as assignments and are to be found in gray boxes in the margins. Similarly there are boxes called group work.

For analytical purposes the written text was divided into sections according to section or paragraph breaks, not unlike the methodology used in TIMSS in the mid-1990s (Schmidt, McKnight, Valverde, Houang & Wiley, 1997; Schmidt, Riazen, Britton, Bianchi & Wolfe, 1997). The number of words in a section was most often between 50 and 150. The area of each analytical unit was used as a measure of quantity. The analysis includes the text of the legends for the visual images as well as the ‘nuggets’. It does not include the short experiments or exercises to be carried out individually, at home or in groups. It is worth noting that the material presented in the book is not divided into distinct lesson plans by the author.

In using the DKS criteria, some uncertainties arose because of language issues. The scheme was developed for an analysis of Greek textbooks and the results reported in English. In applying the scheme to Icelandic texts certain problems arose which need further clarification and investigation.

**Coding, results and discussion**

To avoid repetition and to facilitate discussion the main features of the coding scheme are presented with the results in the next section. Two examples of using the coding scheme are taken (Figures 1 and 2). The criteria for analysis of text and visual images are found in Tables 1 and 2 respectively, with the main results.

**Linguistic analysis**

*Example 1*

Below is a translation of one text section marked no. 55 in Figure 1 called Efnablanda (a mixture) and the results of how it was analyzed.

**A mixture**

In the atmosphere there are many different gases. Among these are three elements, nitrogen (N₂), oxygen (O₂) and argon (Ar) and two compounds, carbon dioxide (CO₂) and water (H₂O). The molecules of these elements and compounds can not combine with each other. The molecules can only mix. Therefore the atmosphere is not called a compound but a mixture. Salt water is a mixture of two compounds, water (H₂O) and salt (NaCl).

This text was analysed as having strong classification. The text presents reasoned arguments and builds on previously acquired knowledge. Also there are clearly defined criteria of what “can be combined” and examples taken of the atmosphere and salt water.

**Framing** is weak since the text is primarily declarative, explaining how things are but the author is neither present nor absent to the reader since the text is written in third person singular or plural.

**Formality** is however moderate since the text is neither highly scientific and formally represented, nor does it use colloquial language. There is some use of specialized terminology (symbols of chemicals) and the number of nouns in a row does not exceed two nouns per time (in Icelandic). The sentences are clear with simple structure and there are equally many verbs in passive voice as in the active voice (in the Icelandic text).
Table 1 Linguistic analysis of two chapters of an Auðvitað book

<table>
<thead>
<tr>
<th>Classification criteria</th>
<th>Formality criteria</th>
<th>Framing criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranges from scientific knowledge to everyday knowledge</td>
<td>Specialised criteria (use of terms, symbols, equations)</td>
<td>The extent to which the text allows the reader to get a sense of active involvement</td>
</tr>
<tr>
<td>Systematic generalisations or not; explicit by:</td>
<td>Nominalisation (nouns or verbs)</td>
<td>• Imperative</td>
</tr>
<tr>
<td>• Large number of observations or not</td>
<td>Syntactic complexity</td>
<td>• Interrogative</td>
</tr>
<tr>
<td>• Use of reasoned arguments</td>
<td>Use of passive/active voice</td>
<td>• Declarative</td>
</tr>
<tr>
<td>• Use of previously acquired techno-scientific knowledge</td>
<td></td>
<td>Person (1st, 2nd or 3rd, singular or plural)</td>
</tr>
<tr>
<td>Scientific taxonomies (clearly defined criteria, the use of these criteria to a fair number of cases and in a common way)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Classification</th>
<th>cm²</th>
<th>Formality</th>
<th>cm²</th>
<th>Framing</th>
<th>cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>1055</td>
<td>High</td>
<td>0</td>
<td>Strong</td>
<td>246</td>
</tr>
<tr>
<td>MODERATE</td>
<td>423</td>
<td>Moderate</td>
<td>288</td>
<td>Moderate</td>
<td>364</td>
</tr>
<tr>
<td>Weak</td>
<td>1525</td>
<td>Low</td>
<td>2715</td>
<td>Weak</td>
<td>2393</td>
</tr>
<tr>
<td></td>
<td>3003</td>
<td></td>
<td>3003</td>
<td></td>
<td>3003</td>
</tr>
</tbody>
</table>

One-third of the text in the two chapters analysed is classified as strong and two thirds is moderate or weakly classified (Table 1). This indicates that the text uses everyday language as well as specialised terms of scientific knowledge. Half of the generalisations in the text come from previously acquired knowledge, a third from reasoned arguments and one sixth from observation. In the case of taxonomy more than half of the text refers to general applications and 40% of these examples are not accompanied by any defined criteria. This means that in the text there are not many clearly defined criteria and those that are found are used in a common way.
In the case of formality about 90% of the text is evaluated as being informal. In the instances where the formality is moderate or high there are few examples of specialised terminology and the use of the passive voice. Two criteria of the assessment of formality, nominalisations and use of passive voice, are difficult to evaluate because of the nature of the Icelandic language. Overall, the syntactic complexity is generally straightforward with few embedded clauses, which makes the text accessible to the reader given the context of it being a science textbook.

The framing of the text analysed is weak. Sentences are mostly declarative and the voice of the author is not obvious. The text demands no active involvement of the reader and the students are often left with the responsibility of what to do with the text they are reading. Here, though, it should be remembered that the suggestions for individual and group projects are not included in this analysis.

In summary, the text relies more on everyday knowledge than scientific knowledge, the text is presented in a relatively informal manner, given that it is from a science textbook, and that the reader often has the responsibility of what to do with the main body of text being read.

Analysis of visual images

Example 2

The visual image marked no. 63 on page 15 in Figure 2 was rated as a hybrid since it is a conventional representation with additional realistic features. The function of the visual image was analysed as being metaphorical; it connotes or symbolises meanings and values over and above what they literally represent. For the reader the role of this cartoon is not obvious and does not connect in an obvious way to the content of these two pages – which is volume. Therefore the classification of the image’s function was analysed as being weak. The overall results of classification is therefore weak (Table 2).

The framing of this visual image is moderate since it is shown from a distance from eye level giving the message that what you see here is a part of your world, something with which the reader is familiar.

The formality of the visual image was analyzed as being low, since the cartoon has no elements of geometrical shapes or alphanumeric strings, presents a variety of colours but few shades of each colour and the background is with details of the whole picture.
Table 2  Analysis of visual images in two chapters of *Auðvitað*.

<table>
<thead>
<tr>
<th>Classification criteria</th>
<th>Formality criteria</th>
<th>Framing criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elements of the techno-scientific code</td>
<td>Vertical angle</td>
</tr>
<tr>
<td></td>
<td>Colour differentiation</td>
<td>• Low</td>
</tr>
<tr>
<td></td>
<td>Colour modulation</td>
<td>• Eye</td>
</tr>
<tr>
<td></td>
<td>Contextualisation</td>
<td>• High</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Function</th>
<th>cm²</th>
<th>%</th>
<th>cm²</th>
<th>%</th>
<th>cm²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realistic</td>
<td>Narrative</td>
<td>233</td>
<td>11%</td>
<td>95</td>
<td>5%</td>
<td>Strong</td>
<td>0</td>
</tr>
<tr>
<td>Conventional</td>
<td>Analytical</td>
<td>514</td>
<td>25%</td>
<td>972</td>
<td>47%</td>
<td>Moderate</td>
<td>648</td>
</tr>
<tr>
<td>Hybrid</td>
<td>Classificational</td>
<td>1325</td>
<td>64%</td>
<td>1004</td>
<td>48%</td>
<td>Weak</td>
<td>1423</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Classification</th>
<th>Formality</th>
<th>cm²</th>
<th>%</th>
<th>Framing</th>
<th>cm²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>High</td>
<td>2071</td>
<td>100%</td>
<td>2071</td>
<td>100%</td>
<td>2071</td>
</tr>
</tbody>
</table>

The results of analysing visual images of the two chapters show that more than 60% of the visual images are weakly classified. That means those images are realistic and do not build up strong boundaries between the specialised techno-scientific knowledge and everyday knowledge. In addition these images are narrative or metaphorical ones.

The degree of formality represents the degree of abstraction in the image. The results show that 95% of the visual images are evenly split between moderate or low formality. That means an emphasis is on colourful images, their background is simple or from real photographic situations and few or no geometrical shapes or alphanumeric strings are present.

Nearly 70% of the images are analysed as having weak framing indicating that the images are viewed from a high and frontal angle and from a close or medium distance.

To sum up, the visual images are generally realistic and have low formality and the boundary line between what is everyday and what is scientific knowledge is blurred. Again the reader is left with the task of what to do with the image.

**Discussion and implications**

This preliminary study indicates that the text in the selected chapters rests more on everyday language than specialised terms of scientific knowledge and 90% of the text is evaluated as being informal with few examples of specialised terminology and the use of a passive voice. Overall, the syntactic complexity is generally straightforward with few embedded clauses, which makes the text accessible to the reader given the context of it being a science textbook. The majority of sentences are declarative and the voice of the author is not obvious. The text demands no active involvement of the reader who is left with the responsibility of what to do with it.

For children, these results mean that almost half of the text does not call for previously acquired knowledge. Also, the text uses applications of clearly defined criteria in a common way. Sentence construction is straightforward and the language is rather more declarative with “non-specialist” terms. Often there is no clear author and the knowledge presented is in many respects “fuzzy” – no clear distinction being made between scientific knowledge and everyday knowledge. The overall message is that everybody can learn science!

The images also tell a story. Images in these two chapters are mostly realistic with a little degree of abstraction. Most images are in colour, cartoon-drawings or colour photographs, viewed from a high and frontal angle and from a close or medium distance. Most of the images are everyday objects and don’t show “discrepant events”. One fourth of images are cartoons with no clear criteria of what constitutes scientific knowledge and one fifth use Lego-blocks very familiar to students. Some legends are informative, others not, and most images need a teacher for further explanations. What then is the message to the learner? That science is not really amazing!

Analysing physics textbooks images Berit Bungum (2008) has seen a move from realistic to conventional images, involving a strengthening of the framing, i.e. less involvement of the learner. Also she reports a shift from involvement in
experiments to involvement in the sense of recognising science in everyday surroundings. Our results point to a similar conclusion.

These results can be interpreted in the light of the national strategy for scientific and technological development. They can also be viewed through the lens of what we know about how children think and learn. What is most important though is to understand better the kinds of tools which teachers use in science teaching and then what level and type of support teachers and children do need. Gericke and Hagberg (2008) explain that school science makes high demands on the teacher’s comprehension of content knowledge as well as the nature of science. Textbooks influence the structure as well as the content of the lessons in the school. With those points in mind our findings will be discussed further with teachers as an opportunity for professional growth and for feedback on the implementation of science and education policy. We will also address the role of the Icelandic language in presenting school science.

References
Naturfaglæreren i møtet med eleven som IKT-bruker
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Abstrakt: IKT har høystatus som læringsverktøy i Norge, maskintettheten er stor, det satses betydelig på IKT-opplæring. Samtidig viser undersøkelser begrenset databruk i naturfagene. Eisner beskriver undervisning som en kunstart som fordrer tilstedeværelse i nuet mens Max van Manen hevder forutsetninger for å fungere som dyktige pedagoger er opplevelsen av inspirasjon. 2002-2003 (n=782) og 2008 (n=516) gjennomførte vi spørreundersøkelser blant 9.klassinger i Trøndelag der vi blant annet ønsket å se hvordan elevene opplevde naturfagslæreren i forhold til faglig og IKT-teknisk fokus og hvordan elevene mente læreren klarte å møte læringsbehovet. Begge undersøkelsene viser at IKT sjelden benyttes. 2008 oppga ca 50 % at det var vanlig at lærer hadde faglig formidling rundt ulike tema når IKT ble benyttet som hjelpemiddel mens 66 % sa at læreren brukte mest tid på veiledning under selve IKT-arbeidet. Det er varierende syn på graden av kontakt med læreren under IKT-relaterte arbeidssituationer med en tendens til at elevene mener de har mindre kontakt ved bruk av IKT. Det kan stilles spørsmålstegn ved om grunnen til den lave bruken er at lærerne fortsatt opplever usikkerhet knyttet til teknisk/praktisk bruk og at kompetansen ikke er god nok, eller om lærerrollen/faglig fokus under bruk av IKT endres så mye at lærerne opplever at IKT er lite egnet. Undersøkelsene tyder ikke på at elevene mener IKT-aktiviteter gir styrket lærerkontakt.

Innledning


Vi ønsket å se hvordan elevene opplevde naturfagslærere i forhold til et faglig og IKT-teknisk fokus og samtidig hvordan de mener læreren klarer å møte elevenes læringsbehov.

Metode

Vi benyttet strukturerte spørreskjema med enkle og sammensatte spørsmål. En del av spørsmålene hadde en evaluativ karakter (Grønmo, 2004) med svaralternativer i form av skalaer, andre var lukkede med svaralternativer. For å få mer helhetlig forståelse av spesielle forhold, gjennomførte vi 2002-2003 også gruppeintervju med elevrepresentanter for de ulike klassene på tre av skolene. Elevene snakket fritt rundt bruken av IKT i naturfagene, åpnes det for nye muligheter knyttet til naturvitenskapelig forståelse.

Resultater
Lærernes IKT-brukerhyppighet i naturfagene
Undersøkelsen våren 2008 viser at 54% av informantene oppgir at IKT på ulike måter aldri eller sjelden benyttes i naturfagundervisningen mens 6% mener IKT benyttes ganske ofte eller ofte (n=516). Det er store forskjeller mellom skolene. Totalt er det ingen nevneverdige forskjeller mellom guttenes og jentenes syn på hyppigheten av IKT-bruk, men også her finnes variasjoner innenfor skolene i forhold til jentenes eller guttenes syn på om IKT brukes mye eller lite.

I undersøkelsen 2002-2003 (n=786) oppga 67% av de spurt om at IKT sjelden eller aldri ble benyttet mens 5% oppga at det ble benyttet ganske ofte eller ofte. Både i undersøkelsen 2002-2003 og 2008 opplyser elevene at det er i forbindelse med

**Lærerrollen ved bruk av IKT i naturfagene**

Ca 50% ga uttrykk for at det vanligste var at naturfaglærer fortalte eller foreleste rundt ulike tema når IKT ble benyttet som hjelpemiddel. 11% mente læreren i stor grad fungerte som datatekniker eller inspirator mens 30% mente læreren oftest fungerte som veileder (figur 1). Samtidig sa omtrent 66% at læreren under bruk av IKT-aktiviteter brukte mest tid på å snakke med eller hjelpe enkeltelever faglig (figur 2).

**Figur 1** Svar på spørsmål 7 i undersøkelsen våren 2008: Tenk på timer i naturfag hvor dere benytter datamaskiner på ulike måter. Hvordan vil du beskrive lærerens rolle i disse timene? (n=516, til sammen 590 svar)

**Figur 2** Svar på spørsmål 13 i undersøkelsen våren 2008: Hvilken setning synes du best beskriver læreren din under arbeid med IKT-oppgaver i naturfag? (n=516, til sammen 385 svar)

**Kontakt med lærer under IKT-arbeid**

Det er relativt variert syn på graden av kontakt med læreren under IKT-relaterte arbeidsformer (fig 3). Det er en tendens til at elevene mener de har mindre kontakt med lærer ved bruk av IKT, men dette kan muligens både være skole- og læreravhengig samt at forståelsen og behovet for kontakt varierer fra elev til elev og er dermed personavhengig.
Droftinger

Teknisk bruk

Elevene mener IKT i liten grad blir brukt innenfor naturfagene selv om det virker som om det brukes noe mer nå enn for 5 år siden. For å kunne utnytte digitale medier effektivt kreves at en behersker de verktøy som trengs. Mork (2006) understreker at det er nødvendig både med pedagogisk og faglig kompetanse samt kunnskap om skolen som institusjon før implementering av IKT kan bli nyttige og gode læringsevne. Det kan stilles spørsmålstegn ved om grunnen til den lave bruken er at lærerne fortsatt opplever usikkerhet knyttet til teknisk bruk og at kompetansen ikke er god nok, eller om lærerrollen og eventuelt faglig fokus under bruk av IKT blir endret så mye at lærerne opplever at bruk av IKT i liten grad er egnet.

Lærerrollen og kontakten med elevene under IKT-bruk

Mange oppgir at læreren bruker fortelling eller forelesning i timer der IKT brukes (fig.1). Formidling gir læreren mulighet for oversikt og kontroll. Samtidig ser det ut som om læreren i stor grad har kontakt med enkeltelever gjennom faglig veiledning og samtaler av ulike slag under IKT-arbeidet (figur 2). Man skulle derfor tro at en stor prosent av elevene ville oppleve å ha mye kontakt med læreren når de drev med IKT-relaterte arbeidsformer. Men selv om undersøkelsen viser til variable synspunkter, er det likevel ikke noe som tyder på at elevene opplever at IKT-aktiviteter gir betydelig mer lærerkontakt (figur 3).

I en veiledningsituasjon kan læreren i mindre grad ha kontroll på faglige spørsmål og utfordringer. Ved bruk av IKT som redskap kreves også teknisk kompetanse. Muligheten for sterk fokus på det tekniske og mindre på faglig konstruktiv dialog, er til stede. Dette kan medføre at både veiledningen og formidlingen kan oppleves mindre inspirerende, mer bundet og kanskje mindre faglig reflekterende. Kan det være slik at en formidrende eller veiledende lærer med faglig og dialogisk tyngde i større grad oppleves trygg, nære og tilstedeværende i forhold til fag og eleven uten IKT som metodisk verktøy enn med?


Konklusjon

Litteratur
Planning science instruction

Creating brochures: An authentic writing task for representing understanding in middle school science
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Abstract: This project is one of several being conducted at the University of Victoria’s Pacific Centre for Research in Youth, Science Teaching, and Learning (Pacific CRYSTAL) supported by the Natural Sciences and Engineering Research Council (NSERC) of Canada. Our focus is the development and implementation of innovative teaching approaches that facilitate increased scientific literacy, within a theoretical framework of fundamental and derived literacy. Our project explores the interaction between literacy tasks and science learning and examines the contributions of direct scientific language instruction embedded in regular science programs. This presentation describes teachers’ use of an authentic writing task—creating an informational brochure—that allowed students to enhance, consolidate, and demonstrate scientific understandings. We examined how teachers implemented the informational brochure activity and how that activity impacted students’ subsequent comprehension and interpretation of novel science concepts that were presented in a brochure format. Participants were grades 6 and 7 middle school science teachers from one local school district. These teachers were part of a larger group that has attended a series of professional development workshops over the last two years. Teacher response to the brochure genre was favourable: at the introductory workshop, all teachers reported that they would use brochures with their science classes. Classroom observations confirmed teachers’ reports that students completed brochures enthusiastically, with an unusually high percentage of assignments handed in on time. Students with a range of special needs were able to produce brochures that met the established criteria. It appears that when middle school students participate in the authentic science writing task of creating informational brochures they are highly engaged and are able to demonstrate their understanding of science concepts.

Introduction
The case that is described in this presentation was conducted at the University of Victoria Pacific Centre for Research in Youth, Science Teaching and Learning (CRYSTAL), supported by the Natural Sciences and Engineering Research Council (NSERC) of Canada. The study is part of a project seeking to develop and explore innovative teaching approaches that lead to increased scientific literacy. In recent large scale assessments of science such as the Programme for International Student Assessment (PISA), the performance of Canadian 15-year olds was reported to be well above average and similar to Finnish students, while Swedish and Danish students were reported to be average (OECD, 2007). In addition, Anderson, Lin, Treagust, Ross and Yore (2007) found surprisingly strong correlations amongst science literacy, reading literacy, mathematics literacy, and problem-solving results for the 2003 PISA datasets at the country-level (0.93-0.99) and the student-level (0.78-0.87). These associations amongst literacy’s defined by adult demands rather than defined by school curricula provide promising insights into connections between language, mathematics, problem-solving, and science literacy. Similar analyses with the 2006 PISA datasets are underway in the Pacific CRYSTAL project. An examination of science literacy instruction in a Canadian context may have implications for instruction in Nordic countries because of their similar successes that could serve as a foundation for more focused literacy-in-science approaches.

Background, aims, and framework
Scientific literacy is the central goal of science education reform internationally and is also a focus in recent science education research literature (Jarman & McClune, 2007; Millar, 2006; Yore & Treagust, 2006). Although there is a lack of consensus regarding a precise definition, many experts agree that literacy in science involves at least two distinct dimensions, such as the fundamental and derived aspects of scientific literacy (Norris & Phillips, 2003; Yore, Pimm & Tuan, 2007). Fundamental aspects include traditional language arts abilities, as well as specific strategies, emotional dispositions and skills, while the derived aspects of science literacy include understanding the big ideas of science (Figure 1). The fundamental and derived senses are interconnected because scientific knowledge is frequently accessed through reading and communicated through writing.

Figure 1 The interacting dimensions of scientific literacy (Norris & Phillips, 2003; Yore, Pimm & Tuan, 2007)
Language, especially print-based language, is essential to doing science and it shapes the construction of scientific ideas as well as communicates these ideas to others (Florence & Yore, 2004). Writing like a scientist involves composition processes in which mental ideas are formed into print-based words and images and submitted for peer-review. This writing process of write-review-revise improves both the conception of the science ideas and the reporting of these ideas. Reading like a scientist – reading the kinds of texts that scientists read in the ways in which scientists would read them – involves drawing inferences from a variety of sign systems including print and images (Fang, 2005, 2006; Lemke, 1998). Scientific research articles typically contain titles, headings, figures, captions, tables, references, footnotes, and abstracts. Figures (representations) appear in a range of forms including photographs, diagrams, maps, and graphs. Reading and writing in science is therefore more than reading and writing print – it is reading and writing images and information in order to make a meaning. Literacy in the context of science includes interpreting and creating external multimodal representations (Moline, 1995; Norris & Phillips, 2003).

Reading and writing are not merely tools to be used in the acquisition and communication of scientific knowledge, but are also tools for the construction of new ideas and understanding. From a systemic functional linguistics (SFL) perspective, science is shaped by the language that scientists choose to use and the language that scientists use is, in turn, shaped by the specialized demands of communicating science (Halliday & Martin, 1993). The language of science construes meaning and through that construal it has developed unique grammatical and textual features, such as high levels of lexical density (the amount of information contained in a text), abstraction, and technicality (the use of specialized terminology), and the frequent use of visual representations (Fang, 2005, 2006; Halliday & Martin, 1993; Trumbo, 2000; Unsworth, 2001). Much scientific knowledge has developed through the use of detailed representations (Huxford, 2004; Martins, 2002). Trumbo (1999) points to how Leonardo da Vinci filled his now-famous notebooks with intricate drawings that captured his observations of the natural world and allowed him to conceptualize his understanding of biological objects and physical events.

Our research team focus is explicit instruction in language, cognitive abilities, habits of mind in science and, where possible, the information communication technologies (ICT) that will lead to improvements in fundamental and derived aspects of scientific literacy. Improved scientific literacy will ultimately foster fuller participation in public debates about science, technology, society, and the environment (STSE), a goal identified as pressing by the science education research community (Council of Ministers of Education, Canada, 1997; Jarman & McClune, 2007; National Research Council, 1996; Tippett & Yore, 2008; Yore, Pimm & Tuan, 2007).

In this particular study, we utilized a write-to-learn approach embedded in science instruction so that students would learn about a genre, strengthening fundamental literacy as well as scientific understanding. The power of genre writing involves multiple representations and is realized in moving between or amongst representations, with knowledge being transformed during the writing process. This transformation requires deep processing and leads to conceptual understanding rather than rote memorization (Hand, Prain & Yore, 2001). Research has indicated that when students are engaged in a writing-to-learn task, they discover that the style and focus of their writing must change to suit the task and that the needs of the audience must be taken into account during the writing process.

An effective writing task should promote scientific literacy and must involve scientific communication skills (Hand, Prain & Yore, 2001). Reports, a mainstay of scientific writing, contain rich descriptions, are written in response to authentic questions, rely on a variety of sources of information, and require synthesis of second-hand information (Keys, 1999). We identified several genres that met these requirements and selected the brochure as a genre that students could use to enhance, consolidate, and demonstrate scientific understanding. In addition, brochures are widely used in real world applications such as travel promotion, health information, and product advertisement and are encountered regularly by readers of all ages (Huang & Yore, 2003). Creating a brochure is therefore an authentic writing task. Although having students design brochures is often mentioned in lists of science writing suggestions (Hildebrand, 1996), and several articles describe how to create brochures (Cooper, 2003), we were unable to locate any published research exploring the cognitive effects of creating a science brochure. However, research on writing summaries of science informational text suggested that limited space requires writers to be critical in determining the main ideas and necessary detail to clarify and support the main ideas and in deleting trivial details (Yore, Bisanz & Hand, 2003). This requirement reduces the chance that the ‘tell all’ approach used by immature writers can be used. Furthermore, brochures encourage the use of multimodalities in which visual images are used to supplement print and present abstract ideas. Brochures also allow writers to use a full range of functional images: decorative, representational, organizational, and interpretational (Carney & Levin, 2002).

Cognitive theories of learning from multimedia are derived from theories of dual coding, cognitive load, and generative learning (Mayer, 2005; Schnotz, 2002). According to these cognitive theories, meaningful learning involves both print and visual input, as well as opportunities to integrate these inputs using a variety of processes. Mayer identifies five cognitive processes: word selection, image selection, word organization, image organization, and the integration of words and images (Figure 2). The multimedia theory suggests that both verbal and visual working memories are utilized during learning, predicting the involvement of verbal and nonverbal systems and their associative structures. The verbal
and visual systems work in parallel to produce two types of mental representations, which are then integrated with one another.

**Figure 2**  A model of the cognitive theory of multimedia learning (Mayer, 2005, p. 37).

Schnotz (2002) proposed an integrative model of words and picture comprehension (Figure 3). The integrative model emphasizes mental representations of multimodal texts and like the cognitive theory of multimedia learning predicts the involvement of visual and verbal processing systems. Because there are interactions between words and pictures, there is not a one-to-one correspondence between internal and external representations: both words and visuals can lead to either descriptive (verbal) or depictive (pictorial) mental representations. This model differs from other theories in that the construction of mental representations is predicted to be a more elaborate process than simply a second coding of information.

The central framework for this study is provided by the fundamental and derived aspects of scientific literacy, as we are focusing on the fundamental component of producing and interpreting science text involving both printed words and visual images. Questions guiding our research include:

- How does the creation of informational brochures impact the subsequent comprehension and interpretation of novel science concepts that are presented in a brochure format?
- How effectively can students demonstrate their understanding of science concepts using the brochure format?
- Does the brochure format allow all students to access and represent information, regardless of academic ability?

**Figure 3**  An integrated model of multimodal comprehension (Schnotz, 2002, p. 109).
Methods and samples
This project utilized a blend of qualitative and quantitative approaches. A mixed-methods approach matched the problem space and the constructs involved, some of which are well-developed, allowing quantitative considerations, and others which are emerging, requiring qualitative considerations. Qualitative approaches include the use of classroom observations, focus groups, semi-structured questionnaires, and student work samples while quantitative approaches include a quasi-experimental comparison using a non-randomized control group posttest only design.

The participants in the larger on-going project are Grades 6, 7, and 8 science teachers from a local school district’s three middle schools. These participants are invited to attend workshops every six to eight weeks in which strategies for increasing scientific literacy are introduced. The workshops, based on existing science programs and resources, highlight opportunities for infusing literacy into science instruction including conceptual growth and vocabulary development (such as accessing prior knowledge, concept maps), reading comprehension (for example, setting and monitoring purpose, detecting main ideas, summarizing, using text features), visual literacy (such as flow diagrams, labeled diagrams, cross-sections, graphs, labeled photographs), genre awareness (including description, argument, directions, cause-effect), and writing to learn activities (for example, posters, PowerPoint presentations, note taking, summaries). At one of the regular workshops, brochures were introduced as a means for students to represent understandings of science concepts. The eight teachers in attendance explored commercial brochures to identify critical design principles and then worked in grade level groups to create their own brochures, either a print-based or electronic template that their students could use in an upcoming activity, so that they would have firsthand experience with the genre. Finally, a scoring rubric for brochures that reflected the design principles was provided, discussed, and customized to meet the anticipated needs of middle school students. Initial response to the strategy was positive, with all teachers stating that they would be using brochures in their upcoming science instruction.

To date, six teachers have implemented the brochure strategy with seven classes across two grades. During classroom visits, we observed teachers implementing the brochure activity, although visits were not made to all classes due to scheduling conflicts, and we also observed students in the process of creating brochures. We collected samples of student rough drafts and finished brochures and teachers completed a semi-structured questionnaire on the effectiveness of the strategy.

We then conducted a non-randomized control group posttest only comparison. A brochure on bridges, a topic not included in the British Columbia science curriculum for Grades 6, 7, or 8, was designed by the research team as a model for instruction. Teachers asked students to read the bridge brochure and then answer ten questions (multiple choice and short answer) based on the information contained in the brochure. Results from classes that had participated in the brochure activity were compared with results from classes who had not yet created their own brochures.

Results
This scientific literacy investigation reveals that the informational brochure strategy is both effective and engaging. Initial teacher response to the activity was positive: at the introductory workshop, all eight teachers reported that they would use brochures with their science classes and six teachers have since implemented the strategy. Those teachers reported that students completed brochures enthusiastically, with an unusually high percentage of homework assignments handed in on time. In addition, students with a range of learning needs were able to produce brochures that met the criteria for the assignment. Two of the teachers who have used brochures in science have since used the brochure activity in other subjects. Student work samples indicated that students were able to represent information in creative ways. The completed brochures also indicated differing levels of understanding of science concepts, and teachers deemed those levels as consistent with or superior to their expectations, based on previous student work.

The comparison of non-random treatment and benchmark Grade 6 and Grade 7 groups revealed that classes in which students had the opportunity to produce brochures tended to score higher on a multiple choice-short answer assessment measure than classes in which students had not yet created their own brochures, indicating that the brochure activity may have a positive impact upon fundamental scientific literacy. In addition, in classes where students had not had the opportunity to create their own brochures, there was obvious confusion about how to read the brochure on bridges, while there were no questions about how to read the brochure in classes in which students had created their own brochures.

Conclusions and implications
Classroom observations indicated that having students create brochures to demonstrate their scientific understanding is a robust strategy. Teachers were able to adapt the activity to match their personal teaching styles and at the same time meet the needs of a diverse group of students. Several teachers incorporated ICT (another fundamental aspect of scientific literacy) into their science instruction utilizing readily available software and hardware. Some teachers also encouraged students to use other resources such as graphing packages, clip art, and visuals.
An inspection of student brochures reveals frequent use of visual images in decorative, representational, and organizational functions embedded in text. These images were not always integrated with the written text, but some outstanding examples revealed connections between words and images and ‘value added’ aspects for the visual images. Further research on the use of brochures may be able to provide verification for one of the cognitive theories of learning from multimedia.

The brochure activity was appropriate for use with a variety of prescribed curriculum topics, including earthquakes, sustainable ecosystems, and energy. Students at all ability levels were able to successfully create brochures. Because the writing area was restricted to six small working spaces the task was not perceived as overwhelming. In addition, support was readily available in the form of ICT resources, so that even students with significant learning needs were able to successfully complete brochures on their assigned topics.

Results indicate that when students have experience with the brochure format (i.e., they create their own brochures on specific science topics), those students are likely to be more able to easily read and comprehend information that is contained in a brochure. Students who did not create their own brochures were more likely to be confused by the reading conventions of the brochure format.

The brochure format enables students to demonstrate their understanding of science concepts in a written format that requires higher level thinking processes such as synthesis of information. The brochure format also provides an opportunity for students to engage in critical reading and writing: space restrictions mean that only main ideas and supporting details can be included and that words and images must be carefully selected to convey information in an efficient manner. It appears that when middle school students participate in an authentic science writing task, such as creating brochures, they are highly motivated. As a result, students can design personalized and creative artifacts that indicate an understanding of the brochure format as well as of the science topics described in those brochures.

References


The importance of science lab work

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Abstract: This study deals with the role of different elements in chemistry lab work and how these elements can contribute to a better understanding of science phenomena and to the development of a more positive attitude to science. The study is carried out from a view of learning that involves both social interactions between students, and between students and teachers, as well as an individual construction of knowledge. That means that higher mental processes in the individual derive from social life. Interactions in the classroom are based on Ann L. Brown's reciprocal teaching strategy. The reciprocal teaching groups are designed to help students to monitor their comprehension. The study is carried out with sixty 14-15-year old students in chemistry education. The data originates from analysis of interviews with the students, interviews with the teachers, students' talk during the lab work, and students' reporting from their experiments to other groups. In the interviews with the teachers they comment on students' work and on discussions during lab work in video-sequences from the lessons. We use a revised SOLO-taxonomy to analyse the quality of students' science talk during the lab work. The students like laboratory work and feel that it is important for their learning of science, and that they also learn about cooperation. The teachers' analysis of the video-cuts from the lessons contains both comments on students' interaction and learning, and reflections on their own teaching. They feel that they learn a lot from this analysis. Reporting to another group in the intervention seems to stimulate the students' abilities to use science knowledge. All groups but one have relational categories according to the SOLO-taxonomy. In 70% of them the quality of the discussions are increasing during the presentation. The presentation to another group stimulates students' learning of science and the quality of their science talk.

Background, aims and framework

This paper presents an investigation of the role of different aspects of chemistry lab work and how these can contribute to a better understanding of science phenomena and to the development of a more positive attitude to science. This investigation is an exploratory study that took place in two science classrooms on the interaction among students and between students and teacher. The interaction in a science laboratory is dependent on the language that students and teachers use. According to Lemke (1990) language and conversation are the most important mechanisms we have for developing, testing and communicating knowledge.

The present study is carried out with a view of learning that involves both social interactions among students and between students and teachers, as well as an individual construction of knowledge. That means that higher mental processes in the individual derive from social life. The introduction of new science concepts is a subtle process that is dependent on fruitful conversation (Leach & Scott, 2003).

We have found that science teachers at the secondary level regard lab work with hands-on activities as the heart of science teaching. On the other hand there is a discussion among science education researchers whether practical work does help students to understand science better, and if students participating in science lab work develop more positive attitudes towards science (Hodson, 1993). We have learnt from a previous research project on lab work at the primary level, that lab work creates a classroom atmosphere with rich communication and improves student ability to talk science (Eskilsson & Helldén, 2003). One problem with practical activities is that students look upon work in a laboratory as doing experiments. If so there is a risk that students do not see the links between theoretical schoolwork and practical work (White, 1996).

From the above theoretical perspective we set up a study of concrete situations during students' lab work in chemistry. We used interactions in the classroom based on Ann L. Brown's (1992) reciprocal teaching strategy. The reciprocal teaching groups are designed to help students to monitor their comprehension.

The aims of this study are to answer the following research questions:

- What is the role of interaction between teacher and students and among students during lab work?
- How does communication during lab work contribute to science learning?
- What are the views of teachers and students of the interaction?

Methods and sample

The study was carried out with sixty 14-15-year-old students and the topics for the lab work studied were acid-base concepts and foodstuff chemistry.

The study consisted of two instructional units. In the 1st unit we studied student work in an ordinary laboratory setting and in the 2nd laboratory session we had interventions based on Brown's ideas on reciprocal teaching (1992). In this intervention the students worked in groups of three, where one was chairperson, one secretary, and one gave a report to another group that had not done the same experiments. All three students in each group took part in the lab work. We interviewed the students and the teachers after each of the two units.
We used a camcorder supplemented with a tape recording in each lab group to document the discussions in the groups. For analysis, the discussions were divided into sequences. In each sequence the students are discussing one separate part of the lab work activity. The sequences were analyzed using a revised SOLO-taxonomy (Table 1) (Biggs & Collis, 1991).

Table 1 Categories used in this study according to a revised SOLO-taxonomy

<table>
<thead>
<tr>
<th>Category in the present study</th>
<th>SOLO-category by Biggs and Collis (1991)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1/ about the experimental procedure</td>
<td>Unistructural</td>
</tr>
<tr>
<td>U2/ relevant concepts</td>
<td></td>
</tr>
<tr>
<td>U3/ concrete aspects of phenomena</td>
<td></td>
</tr>
<tr>
<td>M4/ more than one relevant concept in a relevant way but no integration</td>
<td>Multistructural</td>
</tr>
<tr>
<td>R5/ two or more concepts well integrated in a relevant way</td>
<td>Relational</td>
</tr>
<tr>
<td>R6/ all data are integrated</td>
<td></td>
</tr>
</tbody>
</table>

We chose about 10 cuts from the videotapes illustrating the discussions in the groups during lab work and during the reporting to another group. In interviews with the teachers we asked them to comment on what happens in these cuts.

**Results**

The data in this study originate from analysis of a) interviews with the students, b) the interviews with the teachers, c) student talk during the lab work, and d) student’ reporting their experiments to another group.

**Interviews with the students**

The students think that they learn a lot during laboratory lessons because they like them. They describe how they learn science and how to cooperate. Most of the students mention many advantages with the method used in the second instructional unit: e.g. learning to listen to classmates, explaining experiments stimulates understanding.

Some students did not remember what they had done in the laboratory lesson but when the interviewer asked follow-up questions all of them were able to talk about the lesson. They focused on one relevant domain, and were only able to make simple connections. Half of the students were able to use their knowledge when talking about the experiments in the laboratory.

**Interviews with the teachers**

During the interviews the teachers commented on some video-cuts from the lessons. These comments have been categorized as comments about experimental procedure, student activities, interaction between students and teachers, and learning situations and learning processes.

When analyzing teacher comments three categories are found to be relatively frequent: comments on student activities, interactions, and learning situations. One of six comments was about learning processes. Teacher I focused on student activities and teaching situations. Teacher II mostly commented on learning situations and processes. Teacher III talked about communication and processes. One fourth of the comments from teacher I and II were about communication.

**Student talk during lab work**

When students are doing lab work they talk about what they are doing and then they often use science knowledge and science concepts. In the analysis of the discussions from the tapes, we used the revised SOLO-taxonomy in Table 1.

In six of the nine groups the quality of their science talk improved during the experiments. Students often discussed the experimental procedure when they started each sub-experiment. They used words and concepts introduced in the laboratory lesson as well as in earlier lessons.

**Explaining to a group that has not done the same experiments**

In many groups there were lots of discussions and questions. Only a few sequences were categorised as being unistructural. The categories corresponding to structures of higher quality were more common when students explained their experiments to other groups than during the lab work discussions. The intervention with ideas from Brown (1992) seems to stimulate student ability to use science knowledge. All groups but one had relational categories. Almost 40% of all the statements fall into relational categories.

The quality of student use of science knowledge is higher in the presentations than in the lab work discussions. The students seemed to be more confident in the use of their knowledge. In seven of the presentations at least one sequence was analyzed as relational according to the SOLO-taxonomy. In six of them the quality of the discussions...
increased during the presentation.

**Conclusions and implications**
The intervention stimulated student discussions during lab work. Almost all students were of the opinion that the preparation for the presentation and the work with the written report had stimulated their learning in science. The students talked science during the practical work. When they asked for help they were prepared and able to discuss with the teacher. Student understanding improved as a consequence of interaction and communication among students and between students and the teacher.

Teacher comments on the video-sequences from the lessons included both comments on student interaction and learning and reflections on their own teaching. The teachers stated that they had learnt a lot from this study. Our analysis of the group discussions shows several examples of students talking science, and the use of a revised SOLO-taxonomy points towards an increasing quality in these discussions. The findings in our study are in accordance with Leach and Scott (2003) and Lemke (1990).

**References**
Student study orientations and responses to teacher regulating approaches in science
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Abstract: The Norwegian school reform ‘Knowledge Promotion’, implemented from 2006 onwards, emphasizes that teachers should base their teaching on high ambitions and provide more academic pressure to learn in class. Furthermore, the school reform puts particular focus on schools’ responsibilities for fostering student learning strategies. This paper reports on an empirical study of high school students’ motivation, learning strategy use and self-regulation in science and how they respond to teachers’ regulating approaches (teachers who promote mastery goal orientation and teachers who challenge their students in a positive manner to achieve better). An extensive questionnaire was administered to 532 students (16- to 17-year-olds) in five high schools. The results show that the teacher mastery approach seems to have a more positive effect on boys, while girls respond more positively to teacher academic pressure orientation in science classes. Furthermore, the majority of students respond more positively to the mastery approach, while the academic pressure to learn seems to be more important for the minority. We argue that the assumption of a one-sided negative effect of academic pressure to learn in theoretical literature has to be more nuanced.

Background, aims and framework
The Norwegian education authorities launched a new curriculum reform (‘Knowledge Promotion’) in 2006. The central aim is to strengthen learning outcomes of Norwegian students in compulsory education. Part of the background for this reform are mediocre Norwegian results in large-scale international comparative studies like the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). To fulfill the ‘Knowledge Promotion’, the schools are instructed ‘to stimulate the students to develop their own learning strategies’ (KD, 2006; Elstad & Turmo, 2006). Furthermore, the teachers should provide more academic pressure to learn (in Norwegian: ‘læringstrykk’) in the classes, and base their teaching on higher ambitions for student learning (White Paper 30, 2003-2004). Furthermore, an action plan has been developed to strengthen student interest in science and mathematics (UFD, 2005).

Against this background, it is of particular interest to study relationships between teacher regulating approaches and student responses in science. Extensive research has been done on student self-regulation in science from an individualistic perspective, while teacher–student interactions have not been dealt with to the same degree. Furthermore, it is also important to study differential effects on diverse groups of students. This paper addresses gender and ethnic minority/majority differences in student responses to teacher regulating approaches in science, based on an empirical investigation in Norwegian high schools.

Methods and samples
The empirical data were collected in five high schools in Oslo, Norway. In total, 20 science classes in grade 11 (16 to 17 year olds) participated undertaking a compulsory broad general science course as part of the first year of the academic specialization program. In this paper, we define minority students by language spoken at home most of the time, as given by the students in the questionnaire.

Instruments were developed that aimed to capture as many aspects of student study orientation as possible, including motivational aspects, learning strategies and aspects of student self-discipline. Three descriptive items were used related to the mastery goal orientation encouraged by teachers (Example: “My science teacher wants us to understand the science content, not only memorize facts”). Nine descriptive items related to teacher academic pressure orientation were included (Example: “My science teacher tells the students that they can perform better”). Several of the items were derived from existing instruments which were translated into Norwegian and adapted to the science context (Duncan & McKeachie, 2005; Midgley, Maehr, Hruda, Anderman, Anderman et al. 2000; Tangney, Baumeister & Boone, 2004). Other items were new developments (see also Elstad & Turmo, 2007a; 2007b).

The students responded to a questionnaire consisting of 122 items in total. Initially, they were asked to give background information about themselves regarding gender, socio-economic and minority status. Thereafter, they were exposed to the items on study orientation.

Results
The mastery goal orientation and the academic pressure orientation are positively empirically related (correlation=0.20). This means that according to the students the tendency is for the same teachers to emphasize both orientations. The results show that teacher mastery orientation is positively related to student mastery motivation and interest in science. There are also positive relationships between this approach and student use of learning strategies. Regarding the student–teacher interaction constructs, there are only significant relationships for the boys. Boys reporting high levels of teacher mastery approach tend to respond - according to themselves - more positively to academic pressure to learn and also have stronger preferences for pressure.
The results show fewer significant relationships (p<0.01) between teacher academic pressure orientation and the constructs related to student study orientation. For the girls, the academic pressure orientation is positively associated with critical thinking in science.

We have also compared the relationships between the two teacher orientations and the self-regulated learning constructs for the minority and the majority students. The results show more positive relationships in the majority group for teacher mastery goal orientation, while there are more significant relationships in the minority group for the academic pressure orientation.

**Conclusions and implications**

The empirical findings support the assumption that there are potential positive relations between teacher regulating approaches and interest in science. Ethnic minority students seem to respond more positively to instrumental motivation of the type of requirements and academic pressure to learn than Norwegian majority students. Furthermore, there is a significant empirical connection between teacher emphasis on interest and understanding in science teaching and student interest in science, as expected. These are empirical regularities that require follow-up attention in research. We need a finer distinction between the terms covering teacher academic pressure orientation in order to conceptualize mental processes. Not every form of extrinsic motivation leads to a situation in which the learning of new material becomes more difficult, as certain writers claim (McGraw & Cullers, 1979). However, an increase in ‘teacher academic pressure orientation’ is not entirely positive either. More research is needed to investigate the relationship between academic pressure to learn and motivational aspects and learning results.

Some scholars are of the opinion that the degree of self-determination is significant in relation to how ‘pressure’ can work positively, for instance if regulation is accepted and in harmony with self-beliefs (Rigby, Deci, Patrick & Ryan 1992), and if it supports autonomy (Vansteenkiste, Lens & Deci, 2006). In our material, positive connections can be found for both boys and girls between teacher emphasis on understanding and interest in science on the one hand, and student general mastery motivation in science on the other. There are no grounds for claiming that teacher conduct contributes to gender differences in our empirical material, but other studies document gender-specific patterns in classroom interactions. If we are to find out more about this, we need studies that are more context sensitive. For boys, there is a significant connection between teacher pressure orientation and the tendency for the students to explain away attention from their own weak achievements in science. This is in accordance with research (Eccles, Adler, Futterman, Goff, Kaczala et al., 1983; Parsons, Meece, Adler & Kaczala, 1982) and our expectations. Girls, to a greater degree, attribute their success in the subject to hard work and effort than boys.

Girls and boys respond differently to academic pressure in their schooling. Girls report higher teacher academic pressure orientation than boys and make more use of elaboration strategies and critical thinking when learning science. Furthermore, it is only for the girls that a significant positive correlation is found between pressure and larger subject interest. Further research is needed to investigate causal mechanisms that underlie the statistical correlations and to identify the conditions in which pressure can work positively and negatively on learning progress in science.

This study gives empirical grounds for claiming that students do not perceive every form of academic pressure negatively. Similar results have been reported from other studies (Ibanez, Kuperminc, Jurkovic & Perilla, 2004; Stevens, Hamman & Olivárez, 2007. One possible interpretation is that the value inherent in academic pressure to learn is interjected in the attitude of students. Students recognize the need for a person to push them towards higher achievements and acknowledge that they may benefit from being constrained in their options. The assumption often expressed in the theoretical literature that there is a somewhat one-sided negative effect of academic pressure has to be more nuanced. The challenge is therefore to try to understand better under what conditions teacher academic pressure orientation works positively and when it has a negative effect. Teachers who challenge their students may have students who feel that their teachers are interested in them and are therefore nurtured to achieve beyond their comfort zone. The opposite mechanism is also possible, e.g. when students are exposed to expectations to achieve more than they are capable of themselves as this may trigger a sense of uncertainty and vulnerability. If the student has a positive attitude towards the one exerting the pressure, the student will more easily be able to overcome negative feelings. Relational trust can be understood as a prerequisite for pressure from the teacher to contribute to promoting greater academic achievements in school. ’The presence of relational trust … moderates the sense of uncertainty and vulnerability that individuals feel as they confront … demands’ (Bryk & Schneider, 2002). This is a mechanism, a possible causal pattern, that is triggered (Elster, 2007). Future research should concentrate on identifying and defining prerequisites for pressure to work positively for a diversified student population. Further, knowledge about how pressure can work positively has implications for teaching practices in schools. A better research-based foundation for pedagogical practice is needed.
References


University students' personal ideas about school physics as starting point for dialogic/interactive talk

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Abstract
In this study aeronautical engineering students' views 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 context rich problems, and the discourse when students were deep in conversation during small group work with problem-solving was analyzed (Enhag, Gustafsson, Jonsson, 2007). A main finding in that study was that one student's personal ideas, experiences and questions often drove these group talks. We concluded the physics course with student interviews that had more the qualities of a dialogic/interactive talk around physics as subject-matter, rather than final questions for students to make a statement about. The aim was to highlight students' personal ideas about physics lessons. The pattern for the transcribed student/interviewer conversation showed partly exploratory talks (Mercer, 1995, 2000; Barnes & Todd, 1995) between the student and 'the interviewer'. The paper presents six students' own ideas developed during the exploratory talk parts of the conversation. The focus of the analysis is how the talk around 20 start questions elucidates student ideas after prompting utterances from the discussion partner/interviewer. The research questions are: 1) What 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? Several of the 20 starting questions in the 'interview guide' developed a talk that was exploratory and dialogic/interactive. The way to prompt the students with supportive questions and encouragement helped them to reach a deeper meaning and expression of their ideas.

Background, aims and framework
This study comes from an earlier study of a physics course in which colleagues and I studied the discourse when students were deep in conversation during a compulsory task where students solved context rich problems. The students were doing small group work with problem-solving (Enhag, Gustafsson & Jonsson, 2007). A main finding in that study was that often one student in the group 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.

In this study aeronautical engineering students' views of physics lessons were investigated in a dialogic/interactive talk (Mortimer & Scott, 2003) between a student and a discussion partner in an interview situation. We ended the above-mentioned physics course with student interviews about physics as subject-matter. The interviews had more the qualities of a conversation than final interview questions for students to make a statement about. The aim was to highlight student ideas about physics lessons. This paper shows how students' personal ideas, experiences and questions also give the teacher/interviewer opportunities for a conversation that is interactive/dialogic.

The pattern of the transcribed student/interviewer conversation showed partly exploratory talks (Barnes & Todd, 1995; Mercer, 1995, 2000). This dialogic inquiry about student views of physics lessons builds on the idea that dialogue searches for shared meaning through inter-subjective communication (Hurst, 2002, p. 120). Instead of the triadic discourse I-R-E, initiation – response – evaluation, the exploratory talks found here show the pattern of I-R-F-R-F, initiation – response-feedback – response-feedback (Mortimer & Scott, 2003, p. 41).

The paper presents examples of students personal ideas developed during the exploratory talk parts of the conversation. The focus of the analysis is how the conversation talk related to 20 support questions, elucidates student 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 earlier been divided into two groups and to be able to handle the interviews only one group was invited to the interviews/talks, and 13 out 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. student experience from different physics courses in school,
2. student experience from the recent physics course that had 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 a support to the discussion partner/interviewer to get the conversation going. The conversation was tape-recorded and eight interviews have been transcribed verbatim, and the others partly.

**Results**

The questions from the interview guide were located in the transcripts, and the discussion partner/interviewers 'unexpected' questions and utterances were looked for. The student driven exploratory talks were identified. Some results of how the students' personal specific ideas came up are given in the examples below (1). Some student utterances about physics lessons in general are given (2). A summary of the student experiences of group work (3), and of memories of the context rich problems they used in the earlier course are given (4).

1 The students' personal ideas that appear during the interviews, and the prompting questions that help students to express these ideas.

**Example 1 Student C**

The first main student-driven idea is about the **time limitation** she had felt during all her physics courses in school, as well as during the first course at university. She argues for more time to be allocated to physics lessons. She thinks the teacher has not enough time for each student, and that there is not enough time for the students to keep up during lectures. In the exploratory talk, the interviewer prompts the discussion with the words ‘…and what is it then you would have liked this time for…’ that gives feedback and keeps the discussion going. She wants the time for discussion with the teacher about her personal questions that arise when she studies herself at a slower pace, questions she now never is able to ask in class.

**Table 1** Student C talks about the need for more time for personal questions during physics lessons

<table>
<thead>
<tr>
<th>Interviewer:</th>
<th>Do you find the method of working [at university] similar to that in high school?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student C:</td>
<td>[xxx] …it is so that the teacher, it is rather hard to be teacher for more than 60 persons ..he may have another class too, it is often hard for him or her to have the time…</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>Uhmf…</td>
</tr>
<tr>
<td>Student C:</td>
<td>I remember from high school too, that you wanted more time, or wanted the teacher to have more time for each pupil, but they were always so busy with so many students. Yes, I think that with the time, you do not get things done…</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>‘…and what is it then you would have liked to have this time for…’</td>
</tr>
<tr>
<td>Student C:</td>
<td>It is like this…yes, I felt always that when I studied and read the textbook I could get some question, or need an answer to some question, and if you did not meet the teacher you never got any answers, and then you forget it when you are in the lesson…I would like the teacher to have less students, so that you could get closer to the teacher, sort of, so you could remember those spontaneous questions you always forget and study more.</td>
</tr>
</tbody>
</table>

Her second main idea is about **physics is analogous to a sport**. The initiating question from the interviewer is “How do you view physics in school? Is it difficult or easy, is it important?”. The student expresses herself with half sentences (the typical explorative way). She finds that physics is analogous to a sport; you need to train a lot to be good at it. The talk becomes more intense when the interviewer gives her the prompting question:

‘…What is the aim with the sport physics then?’…

**Table 2** Student C talks about how physics is analogous to a sport

<table>
<thead>
<tr>
<th>Interviewer:</th>
<th>What do you think about physics in school? Is it difficult or easy, is it important?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student C:</td>
<td>It is like, well, any sport…it is important to spend time on it, and train, and practice…[xxx]</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>It was fun how you see it as a sport…</td>
</tr>
<tr>
<td>Student C:</td>
<td>Yes, I see it like that for math too…if you don’t use it, you will forget it, and that makes you worse at it too…</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>What is the aim with the “sport” physics then…</td>
</tr>
<tr>
<td>Student C:</td>
<td>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 taken for granted….if you learn physics then you see things from another point of view….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 get answers to so many questions…you can get answers to how things work but not why they work…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 but it is also annoying not to know how…</td>
</tr>
</tbody>
</table>
Example 2 Student I
Student I’s main idea is how the context is much more important than formulas and calculations. In the exploratory talks the interviewer prompts him to continue develop his ideas by asking “What do you mean by context here…?”

Table 3  Student I’s main idea that the context is important

<table>
<thead>
<tr>
<th>Interviewer:</th>
<th>What do you think about physics in school? Is it difficult or easy, is it important?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student C:</td>
<td>It is like, well, any sport…it is important to spend time on it, and train, and practice…</td>
</tr>
</tbody>
</table>

[Interviewer: It was fun how you see it as a sport…]
Yes, I see it like that for math too…if you don’t use it, you will forget it, and that makes you worse at it too…

[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 taken for granted…if you learn physics then you see things from another point of view.. 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 get answers to so many questions...you can get answers to how things work but not why they work...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 but it is also annoying not to know how…

Example 3 Student S
The talk takes departure in a direct question when the interviewer asks if students S can explain why an airplane can fly. Student S assures the interviewer that he can, and that he learned much about flying already as a child, due to his interest in flying. His interest is based on the good treatment he and his family got during their first air travel to Sweden as refugees from Syria. In a long chain of I-R-F-R-F, student S explains and tells the story of the flight to Sweden, how the the air hostesses treated them on the plane, and how the captain talked to them through the radio….and how everybody applauded when they touched down…how it made him wish for a professional life within aeronautics.

Table 4  Student S’s main idea that his interest of aircraft is based on good treatment he received during his first air travel to Sweden

<table>
<thead>
<tr>
<th>Interviewer:</th>
<th>Are you able to explain to a friend why an airplane can fly?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student S:</td>
<td>Yes, sure!</td>
</tr>
</tbody>
</table>

Interviewer: You feel you can. Could you do that already at high school?
Student S: Yes, I had the basis as I was interested in flying. I did fly before I came here. I have read about it on the Internet and I have read a few books too.

Interviewer: How did you find out about your interest in flying?
Student S: Already as a child. There were not so many airplanes in my life in my country…it was the military that bombed us. I had not been able to fly before. When I flew to Sweden from Syria that was the first time. Then the interest was really aroused.

Interviewer: Yes? It was the flight itself then…?
Student S: Well, I was interested in all these flying military things. And when you the came closer to the airplanes, heavy, big. A body lifting into the air. You get interested! Everybody in my family was sitting there next to me. They were so afraid and so, when we touched down. But I wanted to sit at the window and look down…the others said ‘hi, close the window’ they didn’t want to look down, but I was so interested.

Interviewer: How old were you? Did you think “I want to fly or build an airplane?”
Student S: I was 15. Well, not to build one, but to fly one. And, I was so unbelievably glad to fly ….It was how the air hostesses treated us on the plane, and how the captain talked to us through the radio…. and how everybody clapped their hands when we touched down….it was such fun. You wanted to continue with airplanes you see. One wanted to continue to study something within aeronautics.
Example 4 Student J

Student J’s main idea is that he would prefer more problem solving that is associated with everyday life. The interviewer initiates by asking for what he wanted to learn in the physics course. The response shows how student J finds a physics course “final”, with not much space for personal questioning or ownership of learning. The interviewer gives prompting questions:

“Can you tell me more about that?” and “Maybe another example?”.

Table 5  
Student J’s main idea is that he would prefer more problem solving associated to everyday life

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewer: What did you want to learn during the physics course?</td>
<td>Well, nothing in particular. They contain what… it is written what it contains. But if I could choose myself, then I would prefer more problem solving… that is associated to everyday life… for example how the pressure in the tires are dependent on temperature, but we have had something about that… more such things… not so much formulas… abstract things that are only bothersome.</td>
</tr>
<tr>
<td>Interviewer: Umpfh… can you tell me more about that?</td>
<td>Yes, more?</td>
</tr>
<tr>
<td>Interviewer: Maybe another example?</td>
<td>Yes, take sound then, it is interesting with the Doppler effect. You think when you meet a police car – damn it, I can calculate this! It is fun to feel that, damn it, I can calculate this.</td>
</tr>
</tbody>
</table>

Example 5 Student K

This example shows also how socio cultural circumstances have impact on student interest. Student K is not able to answer the interviewers direct question, but after a prompting question: “What is your first memory associated to airplanes then?”, he tells about all these drawing he made as a child, filled with airplanes, probably because he was living next to an airport.

Table 6  
Student K’s experiences from living near an airport made him interested in aeronautics

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewer: Where does your interest in flying come from?</td>
<td>I don’t know, I have always been interested.</td>
</tr>
<tr>
<td>Interviewer: What is your first memory associated to airplanes then?</td>
<td>Yeah, we lived next to an airport, you saw airplanes all the time that you found fun and fun… that must have been something like that.</td>
</tr>
<tr>
<td>Interviewer: Your parents do not work with airplanes?</td>
<td>No…</td>
</tr>
<tr>
<td>Interviewer: Was these airplanes you saw then?</td>
<td>Yes, it must be… it is such a long time ago that I don’t remember myself, but I have drawings since I was 4 years, and it is airplanes all over…</td>
</tr>
<tr>
<td>Interviewer: You really got interested in aeronautics.</td>
<td>That is why I hope it will come easy to study, because if you are interested, then it is easier to understand the subject.</td>
</tr>
</tbody>
</table>

2 Some student utterances about physics lessons in general

The 13 students give a picture of their experiences from physics lessons expressing how physics lessons consist of lecturing and lab work. They find physics teaching a bit boring due to the passive role of the student. The three excerpts are representative of the general view the group has on physics lessons:

– The teacher stands in front and talks and draws on the white-board, and shows some images … (Student G)

– I think of the teacher I had in high school. He wrote on the white-board – long deductions you didn’t get much out of
– as I was finishing school, we got pretty modern equipment, computers and tracks… then it became more interesting
– experiments, yeah, that is what I think of, experiments and such things (Student K)

– No, I would rather have lab work. That is fine… you can be active all the time. It is too easy to slide down into the chair during lessons (Student M)

3 A summary of the student experiences of group work

The students are positive towards group work. Two excerpts are representative for the students. They find that the increased possibility to solve physics problems with ideas from several perspectives, makes it fun and enriching.
– Positive! Yeah, you bring several brains together…if not one can do it, others can help…and then you find a solution finally. I
could not have solved those problems on my own, but in a group it is possible (Student M)

– I think it is fun. I found it fine…that everybody can help. Everyone can develop sort of, can have opinions…about…everyone
knows something, then you can get the big picture, so to say (Student J)

4 Student memories of the context rich problems they used in the earlier course
The students remember and are able to describe all of the context rich problems they solved during the physics course. They
can describe the context and if they succeeded in solving the problem:

– Yes, it was a piece of wood with a key floating in the water…and a hot air balloon…and the last…was a laser beam through a
PET-bottle with water…and it was also decibel, yeah sound volume from a rock concert (Student K)

– It was something floating…a key with a piece of wood, and a hot air balloon…what more…it was a kind of whale and a
helicopter or something…we didn't solve that one…no, I don't remember any more (Student G)

Discussion, conclusions and implications
Dialogic/interactive talk makes students safe and comfortable, and the exploratory talks often generate stories about
personal experiences and students personal questions. The I-R-F-R-F sequences sometimes come naturally, when the
conversation is intense and fluently because of mutual interest in the content. The exploratory talks starts when the
'interviewer' initiates, by asking for explanations. It continues by requests and prompting questions to go on, often by
taking a leading word from the utterances before…or more directly:

- tell me about…explain to me…how could it be.. what do you mean…try to explain to me

To make teachers aware of different communicative approaches, and to recognise exploratory talks, is a way to enhance
opportunities for meaning-making and wellbeing in the physics classroom. When the talk gets exploratory people often
talk in half sentences, and repeat words. People fill in words and complete each other sentences, to find even better ways
to express an idea.

It is important to prompt the student to explain more and in more detail about personal questions and ideas. These
are key elements of a good discussion and for students increased understanding and development. The discourse
needs to be dialogic/interactive talk – it is then that the student/teacher by united effort reach a deeper understanding
and mutual learning, sometimes far beyond the subject matter, into educational democracy. To bridge the border
between subject and form, might be a way to make students feel comfortable and more willing to take science courses. Emphasizing teacher training in I-R-P-R-P might also be a way to encourage interactive/dialogic talk in classrooms!

Student personal ideas express how important the socio-cultural environment is for student interest to grow. To live
nearby an airport, or to get good treatment during a flight are indications to sufficient reasons to be interested enough
to choose aeronautical engineering.

Time for personal questions and a personal relation to the teacher is important for the students. They wish physics lesson
could give more practical applications and less theoretical refinements. The context has to be emphasized in favor of
formula-driven calculations.

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 students' personal
questions and ideas. She should prompt students to explain more, and in more detail, about these ideas, as they are the
key, both to good discussions, 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 talk by the communicative approach (Mortimer & Scott, 2003) show
that most talk in the classroom is driven by teachers, an authoritative/interactive talk where teachers ask questions and
evaluate student answers. The dialogic/interactive talk, where student 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 the teacher/student talk is to see this discourse on physics as a possible agent of change both
from a content point of view for the benefit of student ownership of learning and for changing the culture of physics
in school. Emphasizing more talk in the classroom raise hopes for enhanced physics teaching and increased student
coopération and ownership of learning (Enghag, 2006). This way of taking time to find out about students personal
ideas and views, one by one, is also a useful instrument, to teach with dialogic/interactive talk, when it is managed in the
classroom involving several students and with physics concepts in focus.

References


Moving into the Zone of Feasible Innovation – towards meaningful science teaching
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Allyson Macdonald  allyson@hi.is

Abstract
Science teaching and learning is considered a complicated challenge both by teachers and pupils. This paper addresses the question of how much change is appropriate in a given context of science teaching and school development. By analysing science teacher motivation and identity and identifying teacher potential to implement the national science curriculum can help us find ideas on activities which might help to change some of the constraints experienced in science teaching. The main findings of the study so far are that by using Roth’s (2007) ideas and Macdonald’s (2007) framework to analyse teachers’ motivation and identity is a deeper understanding of some of the constraints on developing science teaching in schools. Also, the results indicate that the theory of the Zone of Feasible Innovation (ZFI) developed by Rogan and Grayson (2003) is a useful idea when evaluating the level of implementation. When the main constructs of the ZFI are adapted and applied to the national science curriculum in Iceland and the capacity of teachers of science, teachers and school administrators can find new ways to identify possible next steps in developing science teaching in their schools.

Aims of the study
In school development, the decisions of what to do next and how to do it are always difficult. The advent of a new science curriculum in 1999 for Icelandic schools, and a revised version in 2007, with slight changes in emphasis, has encouraged discussions about science teaching. The capacity of teachers to implement the curriculum differ as well as their competence to evaluate what and how much change is appropriate.

The aim of this study is to assess the current capacity of science teachers to implement the national science curriculum and the context within which teachers work. In order to do so we focused on understanding situations in which teachers find themselves and the opportunities and challenges to be found in these situations. It forms part of a larger study on the status of science education in Icelandic schools called intentions and reality with funding from the Research Fund of Iceland 2005-2007. This particular study also received funding from the Research Fund of the Iceland University of Education in 2007. The research question guiding the main study is: What is the nature of the gap between the intended curriculum and the actual curriculum – the intentions and the reality? Subsidiary questions include: What are the main features of the national curriculum in science in Iceland from 1999? What resources are available for science teaching and learning (particularly ICT) and what is their role? What learning and teaching practices are typically found in schools? What influences student choice with regard to science and technology in secondary, further and/or higher education?

Since 1996 all schools have been obliged by law to carry out self-evaluation and the Ministry of Education, Science and Culture is required to inspect self-evaluation methods being used in schools at five year intervals. Most schools have already been through two inspections. The ministry provides guidelines for schools of what aspects of the work of schools must be considered (Ministry of Education, Science and Culture, 1997) but schools choose how they collect the information (Ministry of Education, Science and Culture, 2006). However, the capacity of schools to carry out self-evaluation are very uneven (Ministry of Education, Science and Culture, 2007) and in many communities schools have not had much support for such undertakings.

Today, science education in Iceland faces many serious challenges. National science tests at the end of compulsory school were reintroduced from 2002 until 2008, according to the 1999 curriculum, and have been withdrawn from 2009 in accordance with a new law from 2008 on compulsory education. In future the tests will only be held in Icelandic, mathematics and English. The 2007 revised curriculum for compulsory schools is less detailed than the former one and should be fully implemented in schools by year 2010. Also, the textbooks used for the last decade in the 8th-10th grade will not be reprinted. Many teachers are insecure of what to do next. Most teachers teaching science in compulsory schools are not science specialists and if you are not a science specialist – how will you deal with education through science?

This paper reports on some approaches used in the assessment:
• First, we collected and analysed information through an electronic questionnaire and interviews on the way in which science teachers understand and interpret the demands of the national curriculum for science lessons.
• Second, we explored the motivation and identity of science teachers in three urban schools using Roth’s (2007) ideas on emotion at work and a framework developed by Macdonald (2007) based on Roth’s ideas.
• Third, the framework of the Zone of Feasible Innovation (Rogan & Grayson, 2003) was used to identify areas which might change some of the constraints on science teaching in these schools.
Background

Rogan and Grayson (2003) and Rogan (2007) have developed a theory of curriculum implementation based on three major constructs:

- Profile of implementation (in the classroom)
- Capacity to support innovation
- Support from outside agencies.

Rogan and Grayson (2003) defined six propositions with regard to the theory of curriculum implementation. These are:

- Innovation should be just ahead of existing practice. Implementation should occur in manageable steps.
- Capacity to support innovation should be concurrent with efforts to enrich the profile of implementation.
- Outside support should be informed by the other two constructs, matching outside support with capacity, and capacity with desired implementation.
- All role players need to reconceptualise the intended changes in their own terms and contexts.
- Changing teaching and learning is a change of culture not a technical matter.
- There should be alignment between the three constructs and the primary level (e.g. the learning experience).

Rogan and Grayson (2003) suggest that these constructs and propositions indicate that there is a zone of feasible innovation (ZFI) within which schools and teachers can be encouraged to operate and develop. The ZFI draws on theories of school development, on Vygotsky’s concepts of the zone of proximal development and the importance of social interaction for development, and on the zone of tolerance i.e. the space given to institutions by communities in the change process.

For each construct it is possible to create a matrix (rubric) of relevant factors and the levels of development schools have reached in working towards the long-term goal of implementing the national curriculum (see Figures 1-3). Schools can find themselves positioned at different levels on different factors, both within and between constructs. The rubrics shown here have been adapted to cover the Icelandic national curriculum guidelines, the capacity of those who participate in the school system and support from outside agencies.

### Profile of implementation

<table>
<thead>
<tr>
<th>Level</th>
<th>Classroom interaction</th>
<th>Practical work (fieldwork, assignments, out-of-school work)</th>
<th>The nature and role of science in society</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1** Implementation of the curriculum in the school and classroom (developed from Rogan, 2007).

### Capacity to support innovation

<table>
<thead>
<tr>
<th>Level</th>
<th>Teacher factors</th>
<th>Learner factors</th>
<th>School ecology and management</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>The teacher has outstanding knowledge in science and effective teaching skills. The teacher is willing to change, is resourceful and cooperative. He/she is a vision for innovation and shows professional initiative and leadership at home and elsewhere.</td>
<td>The teacher has basic knowledge and skills to teach science, the teacher has experience of teaching science and is connected with students and colleagues. The teacher is well-connected with students and colleagues. He/she is patient and respected.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>The teacher is competent with reliable knowledge and skills to teach science. The teacher is resourceful and is engaged in professional development of his/her teaching.</td>
<td>The teacher has knowledge but is not an expert.</td>
<td>Example</td>
</tr>
<tr>
<td>2</td>
<td>The teacher has basic knowledge and skills to teach science. The teacher is resourceful and is engaged in professional development of his/her teaching.</td>
<td>The teacher has knowledge but is not an expert.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>The teacher lacks knowledge in science but is a good teacher.</td>
<td>The teacher has knowledge but is not an expert.</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2** The capacity of the school to support innovation (developed from Rogan, 2007).
Support from outside agencies

A team of researchers collected data from schools in five districts in Iceland 2006-2007 visiting three to five schools in each district. The data on science provision was collected from documents, questionnaires, on-site visits, interviews with principals, teachers, pupils and district leaders.

The capacity of the schools with regard to science teaching was assessed by using the Science Curriculum Implementation Questionnaire (SCIQ) (Lewthwaite, 2006; Macdonald, Pálsdóttir & Thórólfsson, 2007). The questionnaire was translated and adapted for use in Icelandic schools, in consultation with Lewthwaite, who developed the questionnaire in his doctoral research (Lewthwaite, 2001). Before visiting schools which took part in the research, those teachers who taught science were asked to complete the SCIQ, and the results were available before the visits took place.

The questionnaire calls for self-evaluation by teachers of the actual and preferred capacity of their own school in implementing the science curriculum. Four extrinsic factors (resource adequacy, time, professional support, and school ethos /the status of science as a school subject) and one intrinsic factor (skills, knowledge and professional attitude) are assessed. There are seven questions behind each factor and teachers rate the capacity of their school on a scale of 1 to 5.

In Lewthwaite’s approach, the SCIQ results can form the basis of discussion and further development within schools (Lewthwaite, 2001) and the SCIQ-questionnaire has been used in New Zealand and in Canada (Wood & Lewthwaite, 2007; McMillan, Lewthwaite & Hainnu, 2007).

The SCIQ-results from 19 schools in Iceland including 105 teachers, show that there was a clear capacity gap between actual and preferred situations (with average gap close to 1.2, Figure 1). For example, with regard to the availability and organisation of professional support the mean rating of teachers of the actual situation was 3.4 and the preferred rating was 4.5. In the schools we visited, the biggest gaps were in the area of Resources (1.5) and of Knowledge, skills and attitude of teachers (1.3).

Interviews were taken in conjunction with the completion of the SCIQ. A first analysis of the interviews and questionnaire data provides some ideas on activities which might change some of the constraints on science in these schools.

The use of SCIQ is valuable in that it gives a base for discussion with teachers about their view the strengths and weaknesses of their school, and the factors that are extrinsic and intrinsic to themselves as science teachers.
Planning science instruction

Figure 4  Mean assessment on the actual capacity (lighter area) and preferred capacity (darker area) for science delivery in 19 Icelandic schools as assessed by 105 teachers on a scale of 1 to 5.

Motivation and identity of science teachers

Few of the science teachers we met in schools had preservice training in science. The interviews with teachers during the school visits indicated that in many cases teachers had been asked by the principal to take on some science teaching, often because they had a background in mathematics or geography. One teacher had been trained as a nurse. Teachers responded to the principals requests in different ways. Some were very reluctant and felt coerced, as if they had no choice. Others were also reluctant but felt they could make a contribution and so complied with the request. We had one example of a teacher who loved science teaching and who inspired the children, but this teacher was something of a loner and worked in ways which met individual interests in the value and relevance of science but did not necessarily strengthen the capacity of the school to offer science. There was an issue here that needed further exploring.

Thus in order to deepen our understanding of the results of the survey and the views of teachers as expressed in the interviews, we turned our attention to teacher motivation and identity in science teaching and analysed the extent to which collective and individual interests of science teachers were being met in schools.

To do so we built on Roth’s proposition (2007) in which he argues that motivation in the workplace is only high when both individual and collective interests are being met in the same activity (p. 60). Working from this assertion Macdonald (2007) developed a two dimensional framework to map teacher motivation and identity (Figure 5).

The vertical axis represents the extent to which individual interests are met in the activity (top is + and bottom is -) and reflect the identity of the teacher as a science teacher. The horizontal axis presents the extent to which collective interests are met (right is + and left is -), i.e. whether the teacher can or does carry out activities which are in the (collective) interest of the school. Competent teachers show high motivation and strong identity (top right quadrant) but coerced teachers show low motivation and weak identity (bottom left quadrant).
The results for the science teachers in the three urban schools are shown in Figure 6. Teachers P, K and D were assessed competent teachers with high motivation and strong identity. Those teachers are all science specialists with science as a subject in their teacher education or a special degree in science. The other teachers represented in Figure 6 are teaching science without any formal background in the subject area and have even been pressed for doing so since “no one else feels up to it”.

This framework gives an overview of science teachers within each school, which can be used to justify the need to work with science teachers in different ways according to their identity and motivation. Also, it emphasizes that science teaching is not only a rational endeavour but also an activity which depends on emotion.

The zone of feasible innovation in curriculum implementation

Further, with teacher response to challenging situations in mind the theory of curriculum implementation (Rogan & Grayson, 2003; Rogan, 2007) was used to discuss with teachers how much curriculum change is appropriate in a given context. The ZFI suggests that innovation should not exceed current practice by too large a gap between existing practice and the demands of the innovation.

With the results of the survey and issues of motivation and identity in mind one of us (AP) discussed the ZFI with nineteen science teachers in two focus groups. These teachers were enrolled in an in-service programme to strengthen
their capacity to teach science, funded by the Ministry of Education, Science and Culture and implemented by the Inservice Department of the Iceland University of Education.

In the group interviews teachers indicated that the theory of the ZFI is a plausible and useful tool for evaluating the levels of implementation within schools and for identifying developmental aspirations and potential contributors and constraints to implementing the national science curriculum. However, they emphasized that they would like to carry out a SCIQ survey in their own schools in order to be able to assess their situation. Also they agreed it would be very useful to be able to compare the survey results with those from other schools in the same municipality, as was done in the SCIQ survey carried out in the main study. Finally, they felt that the ZFI can be a practical and plausible tool to map the landscape of science teaching, but that external help could be useful in developing the indicators and guiding teachers in the evaluation process.

**Conclusions and implications**

Understanding situations in which science teachers operate, and identifying the opportunities and challenges of those situations can provide information on desirable and necessary steps for professional development and the potential of schools and teachers to implement the curriculum. In the process of evaluating the levels of implementation teachers could identify developmental aspirations for stakeholders and potential contributors and constraints to the achievement of these aspirations.

Our research has revealed that a systemic process of innovation involving policies and practice are needed in science education in Iceland in order to strengthen science education. What happens in the classroom is not the private responsibility of teachers. Teaching materials play an important role and research has shown that Icelandic teachers rely heavily on textbooks in their teaching (Macdonald, Pálsdóttir & Grímsson, 2008; Sigurgeirsson, 1992). Teacher motivation and identity is related to the extent of their education in science and their experiences in teaching science. The support they need to be provided with could be identified by using Rogan´s and Grayson´s model of a zone of feasible innovation.

**References**


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:
Reflecting on the science curriculum

December 2008
Reflecting on the science curriculum

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Naturfag nå!
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Reflecting on the science curriculum
What educational objectives do biology teachers aim to achieve?

An empirical interview study of teacher reasoning on aims for the biology course in upper secondary school in Sweden

Maria Petersson map@du.se

Background, aims and framework

The background for this paper is that it forms part of a project studying the science content of the biology course in school, focusing on the topic of evolution. Not much research has been carried out to ascertain which aspects of the content teachers find most necessary (Fensham, 2001). How teachers reason on what aspects to present may be connected with what general objectives teachers find in the course, and how they reason on how to fit and adjust the specific content into the course. It concerns how teachers interpret the curriculum in the current school tradition. The specific content on teaching evolution is not reported here, but this paper will discuss how experienced teachers reason on the general aims for the Biology A course, which is one of the courses in the science program in Swedish upper secondary school. The National Curriculum (Skolverket, 2002) sets out many aims, but it also gives the teachers free rein, within their professional role, to make choices on what aspects to emphasise.

According to Deng (2001, 2007), there are differences between the academic subject and the school subject. The differences may be described by how phenomena are explained and related to each other. Maybe this difference can also be explained in terms of what the knowledge acquired is to be used for (purpose, educational objectives).

Roberts (1982, 1998) and Östman (1995) have described what is emphasised in the content of textbooks in previous studies of science textbooks, but here I look at what aims the teachers emphasise in their reasoning on educational objectives.

Methods and samples

In the light of the fact that Swedish teachers have some professional freedom to interpret the curriculum, this study focuses on what general aims experienced teachers set up for the specific course, Biology A, in upper secondary school.

The interviews have been conducted with 21 experienced biology teachers from schools differing in terms of size, socio-economic status and geography. Eight of the teachers are female and 13 are male. The interviews were performed as semi-structured, deep-interviews (Kvale, 1996). The teachers were interviewed for approximately one hour. All the interviews were taped, transcribed and analysed.

In all the interviews, the following question was asked: “What do you want your students to know and understand when they have completed this course?”

The interviews were conducted as themes, where different themes could be treated in varying depth according to what the teachers were interested in describing as important about the course. For this analysis, apart from direct answers to the above question, statements that the teachers made in their descriptions of the course are noted.

This can be exemplified by:

Helge: The main thing is ecology. That is why we have that first in the autumn and in the spring. Maybe we also add a little, so we can be outdoors. It is so they get a feeling for biology. That is what's important. So they will think that biology is fun. Knowledge, yes they must get a lot of knowledge, but they have to have a feeling for nature and it's got to be fun. It is so rewarding.

First, we considered these statements as significant outcomes. Then, we considered whether they were reasonable interpretations, based on the teachers way of reasoning on the course as a whole. Finally, a transformation of the information (Wolcott, 1994) was made on the basis of our interpretation of how the teachers had reasoned.

What can be derived from this extract is that Helge emphasizes ecology, and that emphasis characterizes all his planning and teaching. Another finding is that this teacher says that it is important to be outdoors; that makes students think that it is fun and this gives the students a feeling for Nature. He finds it rewarding.

Martin answers my question on how he justifies the Biology A course to his students like this:

Martin: How I justified it to the students? I don't think I think like that when I start the course I do not justify it in that sense. I do not try, at least not in the last few years, I haven't tried to start with an overview of the course. I throw myself right into it, for the simple reason that I think it is rather boring to come to a lesson and the first lesson the teacher is supposed to talk about the subject, so I thought that if we plunge right into it, they will get a feeling for what it is.
Reflecting on the science curriculum

These quotations show teachers talking about their conviction that Biology has to be fun, interesting, give feelings.

Results
As a result of analyses of transcripts from interviews with the 21 teachers, over one hundred aims emerged (see Table 1). Apart from the obvious aim that the students are supposed to acquire some knowledge of biology (the content “in itself”), this aim is accompanied by reasons why they should study this and for what purposes. Here these purposes are called all-embracing aims.

These aims, 16 different kinds, can be categorised into five main categories, which are:

- The identity and character of the school subject, biology
- Worldviews
- For further studies
- Science in society
- Quality of life for students

Understanding the traditions and the identity of the school subject, biology, seems to be one important issue. One all-embracing aim described above to illustrate the analysis was the aim to find biology fun, interesting, something to have a feeling for. This aim was found in 12 of the interviews. Significant also were aims to orientate students on the content and methods in traditional school biology, to give a holistic view through evolution and/or ecology, environmental understanding and the history and development of the school subject, biology.

Worldviews constitute a category on how to understand the nature of science, differences between religion and science and how humans have understood science historically.

The content in itself, and emphases on further studies and science in society, seem to be similar to the emphases described by Roberts (1982, 1998) and Östman (1995).

Another category for the school activity is that teachers’ reason on an activity that strengthens the student identity, which gives quality of life for the students, enables them to feel good about themselves, feel safe in nature.

Very little is said on what professional biologists do and in what way biology research is a part of modern society. The descriptions of society and the nature of science aim rather to prepare students to become citizens who can participate in democratic and ethical discussions.

Nine of the teachers who have described to understand the nature of science as an aim for the students, within the category “worldviews” are also those who emphasize evolutionary perspectives within the category: “identity and character” of the school subject, biology.

Conclusions and implications
There are more than one hundred aims presented as what the students are supposed to know when they have completed the course. These aims are most often oriented towards helping the student to enjoy and be oriented on the subject, “school biology”. There are variations concerning the direction in which teachers orient their aims, and concerning how many different aims they are considering in their reasoning on educational objectives.
Table 1  Distributions of all-embracing aims between the five categories, results of interviews with 21 experienced teachers.

<table>
<thead>
<tr>
<th>Aims distributed into number of categories</th>
<th>Number of teachers</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total 5</td>
<td>Total 21</td>
<td>The identity and character of the school subject Biology</td>
</tr>
<tr>
<td>Quality of life for students</td>
<td></td>
<td>Science in society</td>
</tr>
<tr>
<td>Science for further studies</td>
<td></td>
<td>Worldviews</td>
</tr>
<tr>
<td>The identity and character of the school subject Biology</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Quality of life for students</td>
<td>1</td>
<td>x</td>
</tr>
<tr>
<td>Science for further studies</td>
<td>3</td>
<td>x x</td>
</tr>
<tr>
<td>Science in society</td>
<td>2</td>
<td>x x</td>
</tr>
<tr>
<td>Worldviews</td>
<td>7</td>
<td>x  x  x  x</td>
</tr>
<tr>
<td>The identity and character of the school subject Biology</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Quality of life for students</td>
<td>12</td>
<td>x  x x</td>
</tr>
<tr>
<td>Science for further studies</td>
<td>12</td>
<td>x x x x</td>
</tr>
<tr>
<td>Science in society</td>
<td>10</td>
<td>x x x x x</td>
</tr>
<tr>
<td>Worldviews</td>
<td>10</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>The identity and character of the school subject Biology</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>

Number of teachers who address aims in each category

| Quality of life for students | 19 |
| Science for further studies  | 12 |
| Science in society           | 12 |
| Worldviews                   | 10 |
| The identity and character of the school subject Biology | 10 |

Total of all-embracing aims within each category

| Quality of life for students | 48 |
| Science for further studies  | 16 |
| Science in society           | 15 |
| Worldviews                   | 12 |
| The identity and character of the school subject Biology | 11 |

References


Kompetencebaseret naturfagsundervisning – operationalisering af et komplekst begreb
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Baggrund
Det naturfaglige kompetencebegreb introduceredes som teoretisk kategori som en del af indholdet i projektet Fremtidens Naturfaglige Uddannelser (FNU) i 2003 (Andersen, Busch, Troelsen, & Horst, 2003; Busch, Horst, & Troelsen 2003). Naturfaglig kompetence defineres som:
“evne og vilje til handling, alene og sammen med andre, som udnytter naturfaglig undren, viden, færdigheder, strategier og metaviden til at skabe mening og autonomi og udøve medbestemmelse i de livssammenhænge, hvor det er relevant.” (Dolin, Krogh & Troelsen, 2003, s. 72)

FNU-projektet udpegede tillige 4 naturfaglige delkompetencer, som er efterspurgte kundskaber og færdigheder i alle naturfagene og som kan udvikles horisontalt og vertikalt igennem hele uddannelsessystemet:
• Empirikkompetence
• Repræsentationskompetence
• Modelleringskompetence
• Perspektiveringskompetence


Kompetencedybden er et mål for i hvor høj grad en evne er indlært og komme til udtryk som et overfladisk kendskab eller en mere eller mindre integreret del af personens egenskaber, værdier og meninger.


Mål og rammer
De centrale begreber
Begreberne inddeles i en række niveauer, hvor synteseniveauet er målet for bestrebelser på at udvikle naturfaglige kompetencer. Delkompetencebegrebet består af de 4 for omtalte kompetencer, som er naturfagsdidaktikeres bud på nødvendige evner og færdigheder for at udvikle syntesevnen. Dernæst har CAND-medarbejdere foreslået en række generelle karakteristika for de enkelte delkompetencer. Af pladsmæssige årsager er der kun medtaget eksempler på karakteristika fra modelleringkompetencen – og kun gældende for folkeskolens yngre klassetrin, idet det følgende udviklingsarbejde foregår i 3.-4. klasse. Endelig gives eksempler på, hvordan lærere har tolket de generelle karakteristika i forhold til et konkret undervisningsforløb, og hvordan der i et samarbejde mellem lærere og CAND-medarbejdere er udvalgt tegn på, at eleverne har udviklet de målsatte kompetencer. Det bemærkes, at tegnene i nedenstående skema repræsenterer de før omtalte 3 planer i kompetencedybden – færdigheds-, kundskabs- og meningsplanen.
### Skema 1

#### Mål med udviklingsarbejdet

Udvikling af en praksis hvor naturfaglige kompetencekrivelsker er et værktøj, der anvendes af læreren i planlægning, gennemførelse og evaluering

#### Antagelser

Kompetencebeskrivelser kan anvendes i planlægning og gennemførelse af en undervisning, der bevidst sigter mod opnåelse af naturfaglige kompetencer

Der kan udvikles metoder til evaluering af eleverne opnåelse af de tilsigtede naturfaglige kompetencer

#### Mål med forskningsprocessen

- Undersøge og dokumentere en udvikling af undervisningsplaner hvor læringsmålene er beskrevet i kompetencetermer
- Undersøge og dokumentere erfaringer med undervisning, som benytter sig af evaluering af kompetencemål

#### Rammer

Lærerne består of et team på 3 fra samme skole, som har fået tildelt udviklingstid for at være med i projektet. Konsulent og forsker er forfatteren til denne artikel.

**Planlægningen:** lærenes har fået stillet ovenstående begrebsapparat til rådighed og har kunnet udvælge ønskede delkompetencer, der har passet til undervisningsforløbet. Samarbejdet mellem folkeskolærere og CAND-medarbejdere har fundet sted gennem et 3 seminarer, hvor teorier og begrebsapparat er præsenteret, og hvor de 3 naturfagslærere har indledt planlægningen i dialog med en CAND-medarbejder (konsulent). Målsætning, indhold, aktiviteter og evaluering er planlagt gennem SMTTE-modellen (UNI-C, 2007).

**Gennemførelse:** lærfaglærenes har fået stiller ovenstående begrebsapparat til rådighed og har kunnet udvælge ønskede delkompetencer, der har passet til undervisningsforløbet. Samarbejdet mellem folkeskolærere og CAND-medarbejdere har fundet sted gennem et 3 seminarer, hvor teorier og begrebsapparat er præsenteret, og hvor de 3 naturfagslærere har indledt planlægningen i dialog med en CAND-medarbejder (konsulent). Målsætning, indhold, aktiviteter og evaluering er planlagt gennem SMTTE-modellen (UNI-C, 2007).

**Evaluering:** eleverne fører løbende skriftlig logbog over arbejdet, suppleret med, at en lærer optager gruppesamtaler om løsning af nogle af opgaverne vedr. modelbygning. Afsluttende præsentation bliver videooptaget, og efterfølgende foregår fokusgruppeinterviews med elever fra 3. og 4. klasse. Hensigten med interviewet er at få bedre mulighed for at kunne vurdere kompetencedyben end ved den traditionelle fremlæggelse.

**Metode**

Det forskningsstøttede udviklingsarbejde har baggrund i aktionsforskning (Holter & Schwartz-Barcott, 1993).

Gennem udviklingsarbejdet søges tilvejebragt en forandring af undervisningspraksis ved at foretage en handling, som i dette tilfælde består i indførelse af kompetencebegrebet som målkategori. Forskningens opgave er da at følge forandringsprocessen og dokumentere lærernes erfaringer med at bruge kompetencemål. I dette projekt er det en stor grad af deltagermedbestemmelse i processen, ligesom forsker er deltager i evaluatoren af elevernes læring. Validering af resultater sker gennem tilbageførsel til lærerne, hvor lærernes vurdering af tolkningen af analyseresultater er afgørende for om målene er nået.

<table>
<thead>
<tr>
<th>FNU: Syntese</th>
<th>FNU: Delkompetence</th>
<th>CAND-projekt: Generelle karakteristika</th>
<th>Lærerens tolkede karakteristika</th>
<th>Lærers udvalgte tegn</th>
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</thead>
<tbody>
<tr>
<td>Naturfaglig kompetence</td>
<td>Emperikompetence</td>
<td>Forenklinger af komplekst fænomen</td>
<td>Udvælge kendtegn på planeter</td>
<td>kan reproducere fakta</td>
</tr>
<tr>
<td></td>
<td>Repræsentations-komp.</td>
<td>Designe og bygge efter egne ideer og redegøre</td>
<td>Udarbejde overskuelige modeller. Bygge model med planeter, der illustrerer solsystemet i bevægelse</td>
<td>forklarer med faglige begreber solsystemets opståen</td>
</tr>
<tr>
<td></td>
<td>Modelleringskomp.</td>
<td>Fremstille skalamodeller af eksisterende objekter Udarbejde modeller, der illustrerer en faglig sammenhæng Skelne mellem model og virkelighed</td>
<td>Fremlægge projekt med en sammenhæng f.eks. nat/dag</td>
<td>eleven har en mening om den personlige værdi af modeller af solsystem</td>
</tr>
<tr>
<td></td>
<td>Perspektiverings-komp.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Skema 1 |
Reflecting on the science curriculum

Dataindsamling vedr. forskningsmål 1:
Indsamling af undervisningsplaner fra lærerne. Lydbånd af fokusgruppeinterview med lærerne om gennemført undervisning.

Analyse af data vedr. forskningsmål 1:
Undersøgelse af planlægningsmodel, og hvorvidt der er benyttet kompetencebegreber i henhold til gennemgået teori. Analyserede interview ved hjælp af de teoretiske kompetencebegreber og undersøgte i hvilket omfang kompetencemålene har virket kvalificerende for lærernes planlægning. Sammenholde analyse af planlægningsmodel og analyse af interview.

Dataindsamling vedr. forskningsmål 2:
- lydbånd fra elevernes projektarbejde
- videooptagelse af præsentation af projektarbejde
- fokusgruppeinterview med eleverne
- fokusgruppeinterview af lærere (samme som ved mål 1)

Analyse af data vedr. forskningsmål 2:
Undersøgelse af elevers samtaler – i hvilket omfang anvender elever de udvalgte kompetencetegn fra lærernes planlægningsmodel, i mindre formelle arbejdssammenhænge?
Undersøgelse af elevers præsentationer – i hvilket omfang vises kompetencetegn her – og med hvilken dybde?

I fokusgruppeinterviewet undersøges en mindre gruppe elever for deres kompetencedybde, og herunder den personlige værdi og mening, som modelleringskompetencen tillægges.

Konklusion
Den anvendte metode forventes at kunne indikere, hvorvidt lærere kan have gavn af det naturfaglige kompetencebegreb i planlægning, gennemførelse og evaluering af naturfagsundervisning, og hvorvidt elevers læring kan følges som en udvikling af deres kompetence – bredde og dybde. Projektet er imidlertid kun at betragte som et pilotprojekt, som kan danne baggrund for et større udviklingsprojekt, hvor lærere med mere varierede forudsætninger deltager i et efteruddannelsesforløb.

References

Naturfag nå!
Gudrun Jonsdottir gudrun.jonsdottir@umb.no

Innledning
Reflecting on the science curriculum problemområder er kjennetegnet ved høy grad av systemusikkerhet og verdiorientering. Problemer som reduksjon av ozonlaget, global oppvarming og genmodifisert mat er eksempler på denne typen problemstillinger (Ravetz, 1999; Kolstø, 2003).

De faglige innspillene i debattene fungerer på samme linje som andre innspill som kommer fra politisk hold, næringslivet eller miljøvernorganisasjoner. For å kunne delta i den demokratiske debatt er det viktig å ha en grunnleggende kunnskap om naturvitenskap og teknologi. Når vitenskapen anvendes på stadig flere områder og forskningstemaene blir mer sammensatte, øker usikkerheten - både hos leg og lærd. De unge møter denne debatten i hverdagen (Beck, 1997; Ziman, 1996; 2000; Kolstø, 2003; Sjøberg, 2004).

Når jeg i paperet stiller jeg spørråmet: hvorfor lære naturfag?, tar jeg utgangspunkt i et sentralt aspekt ved mitt doktorgradsarbeid, som omhandler 16-17 årige jenter og deres møte med naturfag.

I offentlige debatter om realfag er det rekrutteringsaspektet som er mest fremtredende: Hvorfor lære naturfag?, jo, fordi det er mangel på kvalifiserte realister til industri og naturvitenskapelig relatert forskning. Det lar seg vanskelig gjøre å være uenig i at naturvitenskapelig kunnskap er viktig for velferden og at denne typen kunnskap kan være både kreativ og kul. Ønsket om å styrke rekrutteringen til realfaglige studier er derfor legitimt.


Teoretiske perspektiver

I analysene setter jeg dannelsbegrepet inn i en samtidig kontekst, ved at jeg relaterer det individuelle dannelsesperspektivet til teorier om senmoderniteten (Beck, 1997). Det er spesielt to nøkkelbegreper, hentet fra Becks teori om risikosamfunnet som har vært viktige i analysene. Disse to nøkkelbegrepsene, risiko og individualisering, anvendes som to viktige faktorer i kontekstualisering av det individuelle dannelsesperspektivet (Beck, 1997).

Empirisk tilnærmning
Utvalg

Feltarbeid

Det andre intervjuet fant sted godt ut i andre semester, etter at jentene hadde begynt på videregående skole. Intervjuformen jeg benyttet var halvstrukturert intervju (Kvale, 1997). Jeg la vekt på at intervjuet i størst mulig grad skulle være preget av en dialog. Hovedtemaet i dette intervjuet var jentenes forhold til naturfag i forskjellige kontekster og arenaer. Jentene møter naturfaglig kunnskap i hverdagen på skolen, i omtale og debatter i media og i reklame. Et annet viktig tema var deres syn på og tilnærming til vitenskap. Jeg tok utgangspunkt i noen hovedspørsmål i intervjuguiden som ble fulgt opp med andre relevante spørsmål under samtalen.
Analysearbeid


Jeg har vekslt mellom induktive og deduktive fremgangsmåter. I praksis har arbeidet med analysene bestått av tre faser som jeg har alternert mellom: Gjennomlesing av hele materialet – den letende fasen, utarbeidelse av kategorier – fasen for kjenntegner og gjennomlesing av data i lys av tentativer kategorier – fokuseringsfasen.

Funn


Jeg har brukt metaforen transitthall mellom det moderne og det refleksive moderne, for å beskrive dette. I skolens naturfagsundervisning følger de at de møter den veletablerte naturfaglig kunnskapen. Skolens naturfag opplever jentene som faktapreget og arbeidskrevende. Jentene etterlyser undervisning i naturfag som kan gi dem holdepunkter til å orientere seg etter i møtet med nyheter, informasjon og reklame i media som de føler seg berørt av. De temaene jentene etterlyser og ønsker mer av er preget av problemstillinger som handler om risiko.

Jentenes tanker om risiko har jeg i analysene knyttet til begrepet individualitet. Jentenes beretninger om møter med naturfaglig kunnskap gir gjenklang i forhold til begrepet individualitet (Beck, 1997). Når stadig flere av våre livsområder i det refleksive moderne frikobles fra de rammene tradisjonen har gitt, fører dette til at vi må ta kappe beslutninger, valg og standpunkter. Jentene opplevelse av viktige valgsituasjoner og at de føler at de er ansvarlige for seg selv og sin livssituasjon er en viktig premiss for å forstå deres møte med naturfaglig kunnskap.

Selvstendige og myndige mennesker


Jentene i min undersøkelse uttrykker et ønske om at skolen skal ta tak i problemstillinger knyttet til disse debattene. De trenger hjelp til å ta stilling til den naturfaglige kunnskapen de møter i hverdagen. De vil reflektere selv over hva mennesket er, men signaliserer at de er avhengig av sine omgivelser for å få til dette.


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References

Challenge diversity: new curricula for natural and computer sciences and engineering
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Background
Despite extensive social changes and intensive political efforts to establish equal opportunities, women are still a minority in the fields of natural sciences and technology related studies, as well as in the respective professional fields. At the same time, technologically oriented studies are not per se less interesting for women, but their motivation, specific interests, learning styles, goals and demands often vary significantly from those of men. The rather broad interests of women often are directly opposed by a unilateral, outdated, techno-centric learning-/training program, which is not only unattractive to women (and an increasingly high number of men), but also bypasses the actual demands of modern education and the job market. The complexity of global markets, social relevance, economical objectives and ecological limits call for integrated thought and action, which has to be accompanied by interdisciplinary approaches.

A lack of diversity in technical conception and development reduces the potential of ideas and innovation within a society, as well as the quality of products. For a company the result of this lack of diversity can be a loss of competitiveness. Additionally, the absence of women in the technical fields amplifies another problem: the long and medium-term demand for qualified specialists is increasing and can no longer be satisfied by men alone [1, 2, 3]. One of the reasons for this development is the image of studies related to engineering or natural sciences. These courses often are connected to a disadvantageous image that completely conflicts especially with feminine preferences and approaches. The very technocratic, dull image of programs for engineering and natural sciences repels young women and increasingly young men. The curricula of these courses have to change towards a support of non-technological basics and social skills. This would not only support the interests of women and men but additionally follow the demands of the economy.

The Galilea project, located at the Technische Universität Berlin (University of Technology Berlin), is developing several models of co-educative, gender-sensitive model-courses within the areas of Natural Sciences, Computer Sciences and Engineering. In this article we will first discuss the general ideas behind these programs and then present some specifics on the first model-course "Bachelor/Master of Natural Sciences and Information Management" that started in fall 2007 at TUB.

The Galilea project
Within the project Galilea several model courses for the areas of Natural Sciences, Engineering and Computer Sciences were developed [4]. The courses have been developed on the basis of two ideas:

1) A thorough theoretical education and training of computer skills:
One result of the actual speed of technological advances is a growing need of highly skilled, flexible and creative scientists and engineers. In order to keep up with these demands, an adequate education must emphasize the need for a solid theoretical basis. Key to this basis is a good knowledge of mathematics: the classical qualification for engineers and scientists. In the past years math also has become increasingly important in fields where its use is not so apparent since computers have entered every area in modern working environments. They lead to an extended use of mathematical models and simulations in finance, logistics, medicine, or other areas. All these applications thus rely on skilled personnel that can evaluate the output and draw the correct conclusions. This makes mathematics a key skill not only for classical engineering and natural sciences but also for economics, life sciences and of course computer sciences itself.

Regarding the new Bachelor program the emphasis on a mathematical education also serves another purpose: Math has proven to be more attractive to women than other areas associated with technology. Since the end of the last century, in Germany more women than men started studying mathematics (see e.g. [5], numbers originate from the German Federal Statistical Office [6]). Until now this development is not reflected in the numbers of students that actually graduate in this area but it serves as a reliable indicator that women are attracted to math. Within the project Galilea we therefore emphasize the mathematical education in order to use it as a door opener. We hope to thus make other fields related to technology more attractive to women. Another important part of these new courses is the integration of an extensive training of computer skills. Besides training the application of commonly used software, students learn one programming language and have to pass a course for numerical mathematics.
2) A broad variety of elective courses and a mandatory internship:
An important part of all newly developed Bachelor and Master programs is a high number of (compulsory) elective courses. Students can (with some restriction e.g. in the natural sciences) freely choose from these courses according to their interests. On the one hand this helps integrate inter- and multidisciplinary aspects into the studies. On the other hand these courses can be used to allow students to even switch between majors. In the program "Bachelor and Master of Natural Sciences and Information Management" students can e.g. start the program in biology, take additional courses in physics and later switch their main area of research completely towards chemistry. This possibility is implemented to counteract the influence of the negative image some natural sciences have, especially among women. This approach allows starting studies in an area students feel comfortable in while at the same time offering them to learn about related areas. It stresses the connections within different areas of research and encourages students to "think outside the box".
A change of perspectives is also the idea behind the mandatory internship students have to complete. During all programs students get an intensive training not only of their theoretical skills but also in areas like time or project management. Internships give students the opportunity to practice these skills in "real life" and learn about possible work areas. For universities, internships provide the possibility to get direct feedback from companies and stay in touch with the demands of the job market.

The first of these model-courses is called "Bachelor/Master of Natural Sciences and Information Technology" and started in fall 2007 at the University of Technology Berlin. Approximately 30 students (50% female, 50% male) will attend this program. Besides the general education guidelines already presented in the section above, this program is designed to connect natural sciences with the demands of the information society. This means that first of all students get a thorough theoretical education in the natural sciences with all the benefits mentioned earlier. Additionally this program includes special courses aiming at information retrieval and information management in modern areas of research. Students learn how to work with the increasing amount of information and learn about communication and presentation techniques. This not only enables them to work efficiently in their area of research, it also can be the first step into completely new areas like journalism. A significant part of the course is a mentorship program that contains organizational, social and technical elements. Each student will be assigned a personal mentor who provides assistance during the whole program. The goal is to increase the social and technical experience, and to improve the educational atmosphere by a close mutual relationship. It is expected to considerably increase motivation [7] and performance, especially of women.

Conclusion
Universities specializing in engineering and natural sciences educate the majority of specialists in these areas. Therefore, they play an important role in establishing equal opportunities in technology related studies. Developing programs that are equally attractive for both women and men and that reflect the demands of modern societies is one of their most important responsibilities. In the past years, numerous efforts have already been made to increase the number of female students within technological disciplines.

In November 2006 the GaILeA project started the development of completely new Bachelor/Master programs. Berlin University of Technology has recognized the high importance of equal opportunities, and is actively supporting these new model-courses. The project does not only intend to gain more female students, TU Berlin furthermore wants to play a leading role in addressing the new challenges in economics, sciences and society by new approaches in education. The goal is to support the development of a new image of courses in natural and computer sciences and in engineering to motivate women and men equally, and provide them with attractive career opportunities [8-10].

Due to the Bologna declaration [11, 12], European universities right now provide an ideal setting for these types of highly experimental model-courses. In order to offer courses that can be easily compared across borders, traditional programs are currently modularized into Bachelor and Master courses. This implies that the contents of the studies are reviewed and at least in some cases, modernized. Especially universities in Germany therefore have to undergo extensive changes, since the traditional structures of education (e.g. the German Diploma or the Magister) have proven to be in large areas not compliant to Bachelor and Master courses. Thus, it is the perfect opportunity to integrate gender-sensitive components into curricula and teaching models.

References
Naturfagslæring på tværs af institutioner – hvordan skabes bedst motiverende og sammenhængende naturfagsformidling fra børnehaveliv til skolehverdag

Lars Domino Østergaard ld@aalsem.dk

Baggrund

I den seneste PISA undersøgelse af børns kompetencer indenfor bl.a. naturvidenskab, kan der udover danske elevers rent vidensmæssige score også læses, at deres opfattelse af naturvidenskabens generelle værdi er den mindst positive overhovedet (Egelund, 2007). Endvidere udviser de danske elever også en generel lav interesse for at beskæftige sig med naturvidenskab (Egelund, 2007).

En måde hvorpå denne holdning kan forsøges ændret, er ved i en tidlig alder koordineret og målrettet at motivere og engagere børn til at beskæftige sig med naturfag, for derved at stimulere dem til bibeholde og videreudvikle den naturlige nysgerrighed for omverdenen, som de fleste børn i en tidlig alder har. Vores tese er derfor, at det er vigtigt, at der skabes sammenhæng og progression mellem den naturfagsformidling, som børnene møde først i børnehaven, siden i 0.klasse (tidligere børnehaveklasse) og endelig i indskolingen.

Formål

Formålet med projektet er at opstille og evaluere en metode, hvormed det er muligt at skabe sammenhæng i den naturfagsformidling, som børn fra børnehaven til indskolingen bliver tilbudt. Ved at udarbejde koordineret og sammenhængende læseplaner for naturfagslæring i de pågældende institutioner og i disse planer bevidst arbejde med motivation, naturfaglige begreber og arbejdsmetoder, forventer vi at børnene får en større forståelse for både naturfaglige begreber, deres sammenhæng og naturfaglige arbejdsmetoder, og samtidig forbliver nysgerrige og til stadighed vil være motiveret for at arbejde med naturfag.

Undersøgelsesspørgsmålene er:

- Hvordan etableres et frugtbart samarbejde om naturfagsformidling og naturfagsundervisning i børnehave, 0. klasse og indskolingen?
- Hvorledes kan man i daginstitutioner og skole stimulere børnene, så de får erfaringer med natur og naturfønomener som kan danne basis for udvikling af deres naturfaglige kompetence?

Hvad skal børnene lære – og på hvilken måde skal de lære det?

En af de store udfordringer i projektet har været at skabe sammenhæng i den naturfagsformidling, som børn møder igennem deres udvikling. En formidling der foregår på baggrund af forskellige kriterier/lovgrundlag, og som bliver formidlet af pædagoger og lærere med vidt forskellige forudsætninger og faglige baggrunde.

For at belyse det første spørgsmål, var det nødvendigt at nærlæse læseplaner og lovgrundlag for de forskellige institutioner. Desuden blev erfaringer fra et tidligere udviklings- og forskningsprojekt inddraget (Elmose, 2004, se Resultater og eksempler).

Det andet spørgsmål er søgt besvaret ved at kombinere børns frivillige og ofte flow-prægede leg (Andersen, 2008; Østergaard, 2005) med deres naturlige nysgerrighed og opmærksomhed, de tit udviser, når de bliver præsenteret for aktiviteter, der har relation til naturfag (Fischer & Madsen, 2001), og endelig sammenholde det med de læringspotentiale, der kan fremstimuleres i børns leg og deres refleksioner (Samuelsson, 2005).

I børns leg er der faktorer, der gør, at de gerne vil vende tilbage til en bestemt leg – en bestemt aktivitet – som de har
haft en god tid og oplevelse med. Da der samtidig i børns leg i naturfagligt stimulerende omgivelser er fundet tegn på legeadfærdstyper, hvori børnene anvender naturfaglige arbejdsmetoder (Østergaard, 2005), er det oplagt at pædagoger, børnehaveklasseleder og lærere bør inddrage legens motiverende faktorer i deres naturfagsformidling (for yderligere diskussion af motiverende faktorer, se Østergaard, 2007).


**Metode**
Indeværende projekt er udført som et aktionsforskningsprojekt (Friedman, 2001), hvor to institutioner med tilknyttede pædagoger, lærere samt børn fra børnehave til og med 3. klasse deltog over en toårig periode. Læreplanerne for naturfagsformidlingen blev løbende planlagt, diskuteret, og revideret af pædagoger, lærere og involverede udviklings- og forskningsansvarlige. De perioder, hvor naturfagsformidling var i fokus i børnehaven eller i skolen blev der foretaget klassesumobservationer, skrevet feltnoter og taget stillbilleder. Før og efter forløbene blev både pædagoger, lærere og udvalgte børn interviewet (semistrukturere gruppeinterview, Kvale, 1994).

**Resultater og eksempler**

**Tabel 1**  Eksempel på læseplansbånd (LPB), som de blev skitseret for to temaer fra børnehaven til tredje klasse.

<table>
<thead>
<tr>
<th>Trin</th>
<th>Børnehave</th>
<th>0. klasse</th>
<th>Første klasse</th>
<th>Anden klasse</th>
<th>Tredje klasse</th>
<th>Eksempler på begreber, hvormed det er muligt at skabe progression</th>
</tr>
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<tbody>
<tr>
<td>1. Natur og produktion</td>
<td>Insekt Zoo (emne 1a)</td>
<td>Bænkebidere (emne 1b)</td>
<td>Træer (emne 1c)</td>
<td>Skovbunden (emne 1d)</td>
<td>Jord (emne 1e)</td>
<td>Klassifikation, insekter og andre smådyrs navne; livsbetingelser; fode; bytte-/rovdyr; insektklasse; ...</td>
</tr>
<tr>
<td>2. Vejr, vand og liv</td>
<td>Efterår (emne 2a)</td>
<td>Vand (emne 2b)</td>
<td>Årstider og vej (emne 2c)</td>
<td>Vejret (emne 2d)</td>
<td>Vand og vej (emne 2e)</td>
<td>Regn, slud og sne; vands tilstandsformer; temperatur; smeltning; fordampning; faseovergange; em, vands kredsløb; ...</td>
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</tbody>
</table>

Hvert af de fem temaer i læseplandsbåndene er opdelt med en række deleemer, der tilsammen dækker mange aspekter fra det overordnede tema og de er strukturerede på en måde, så det er muligt at arbejde med progression af naturfaglige begreber og arbejdsmetoder, som har relation til de enkelte emner.

Ved at arbejde med de fem læseplansbånd fra børnehaven og opefter, er det muligt at opfylde kravene i de officielle læreplaner og undervisningsmål for alle institutioner.

Læreplanerne for de enkelte deleemer var koncentrerede om få aktiviteter, hvor børnene på en legende og motiverede måde skulle anvende naturfaglige arbejdsstegener til at tilegne sig viden om udvalgte naturfaglige begreber. Arbejdsstegener og begreber var i alle tilfælde udvalgt med respekt for børnenes alder og læringsmæssige udvikling.


Senere, i 0. klasse, skulle de samme børn arbejde mere indgående med et enkelt af de insamlede smådyr (bænkebidere). De skulle undersøge deres livscyklus, deres vækstbetingelser, relation til andre dyregrupper osv. Børnene
skulle foretage mindre undersøgelser og eksperimenter, og de skulle bl.a. arbejde med det at forudsige (fx hvor en bænkebider foretrækker at leve). Det tidligere introducerede begreb smådyr blev skærpet (bænkebidere er ikke insekter) og begrebet fødekæde blev behandlet.

**Konklusion og perspektivering**

Analyse af de indsamlede data viste, at børnene på alle trin (fra børnehave til 3. klasse) arbejdede engageret og koncentreret med de udvalgte aktiviteter, og at de tilegnede sig naturfaglig viden, når de selv var aktive og skulle anvende naturfaglige arbejdspraktik for at lette frem spørgsmål og opgaver, de blev udfordret med.

Formidlingsmæssigt viste resultater fra projektet, at det er fordelagtigt at fokusere på få aktiviteter og (udvalgte) naturfaglige arbejdspraktik og begreber, for derigennem at kunne motivere og engagere børnene til at beskæftige sig med natur og naturfænomener. Arbejde der ikke kun skærmer børnernes (naturfaglige) færdigheder, men også tilvejebringer viden og erfaringer, hvorpå de kan videreudbygge deres naturfaglige kompetencer.

De konkrete og gennemarbejdede læseplanbånd fungerede både for pædagoger og lærere som en god ramme for etablering af samarbejde på tværs af institutionerne. Uden at fratage formidlernes autonomi, har de fået et værktøj, hvormed de kan planlægge og perspektivere deres forudsætning både i relation til hvad børnene tidligere er blevet præsenteret for, og hvad de senere skal arbejde med.

Resultaterne kan bidrage til etablering af en ny praksis, hvor pædagoger og lærer i samarbejde på tværs af institutioner udvælger aktiviteter, arbejdspraktik og begreber, der kan være med til at skabe sammenhæng i børns læring af naturfag. Ved at arbejde hensigtsmæssigt med de udvalgte aktiviteter, vil det være muligt at bibeholde og evt. skærpe børnernes nysgerrighed og motivation for at beskæftige sig med naturen og dens fænomener.

**References**


**Education for sustainable development in the Icelandic compulsory school curriculum**

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**Background, aims and framework**

The primary aim of the ActionESD project is to investigate ways in which education for sustainable development can be strengthened in schools. Thus the chief goal of the research that is presented here is to analyze and interpret the policy of the Icelandic government, and put it in the context of international and local policy. We are following the lead of many other researchers of seeing education for sustainable development not only as an extension of environmental education; we are drawing on other curriculum traditions, such as development education, consumer education, life skills education, multicultural education etc. (e.g. Chatzifotiou, 2006; 2006; Lundegård & Wickman, 2007, Jóhannesson, 2007, Rauch & Steiner). We have also attached our understanding of the education for sustainable development to developing students’ action competence (Breiting & Mogensen, 1999; Jensen & Schnack, 1997).
We believe that educational action for sustainable development is based on the following three principles:
1. Developing knowledge for and about sustainable development
2. Encouraging respect for nature and society, and
3. Nurturing a sense of shared responsibility for our common future.

These three principles harmonize and can be included within the policy of the Icelandic government about three pillars of sustainable development, economic growth, social welfare and environmental protection, and the goals of the United Nations decade for sustainable development (UNESCO, n.d.). Based on the above we developed a key for analyzing documents, which contained seven elements:

K1. Values, opinions and emotions about nature and environment
K2. Knowledge that will help in using nature wisely
K3. Welfare and public health
K4. Democracy, participation, action competence
K5. Equality and multicultural issues
K6. Global awareness
K7. Economic development and future prospects

The research is an integral part of a research and school development project where the research team will work with six early childhood, compulsory and secondary schools in Iceland in the next two years, aiming at advancing the understanding of what education for sustainable development is and what it can do.

The ActionESD project will:
• Benefit students by increasing their knowledge of natural resources, developing their respect for nature and society and encouraging a sense of shared responsibility for ensuring a quality of life acceptable to all.
• Benefit teachers by encouraging teachers to work with each other, with their local community and with the support of educational researchers in developing their own knowledge, skills and understandings about sustainable development.
• Benefit schools by supporting the development of school-wide actions built on the ideas and values of the schools and local communities with regard to sustainable development.
• Extend the knowledge base about educational action for sustainable development among researchers in Iceland.
• Support the development of a Nordic and a northern view on ESD which builds on democracy and educational traditions.

Methods and samples
We analysed curriculum documents for early childhood, compulsory, and secondary schools in Iceland using the seven point key outlined above.
We also studied school policy documents from various municipalities, Local Agenda 21 documents, the policy of the teacher organizations, the policy of environmental non-governmental organizations and other civil society organizations to see if there are other resources for the schools in the quest for education for sustainable development.

Results
The main findings of the study are that the curriculum guidelines of all school levels give opportunities for an increased emphasis on education for sustainable development. However, these opportunities are not explicit, and sustainable development itself is seldom mentioned. When using the seven point key for analysis we found more evidence of indicators of education for sustainable development.

Most of the indicators in the curricula about education for sustainable development were related to ecological knowledge and skills to make decisions (K2 and K4). Aims found in K1 related to values, opinions and emotions about nature and environment highlight the view that knowledge must make a difference to us and must be useable knowledge. The aims for democracy and participation (K4) are rather common stipulations about children’s development and knowledge, but also about children being able to express themselves. These aims can encourage action competence for sustainable development (K4).

In the curricula the indicators varied according to school level. Also we found in our analysis work and interpretation that some aims could be grouped into more than one point of the key.

When using the analytical key to analyze examples of policy of local authorities and the policy of selected non-governmental organizations evidence was found of general back-up for the schools in the quest for education for...
Reflecting on the science curriculum for sustainable development. However, teachers and schools must seek out that support. The support available for schools regards both issues and the ambition of local authorities to support their schools. Also, non-governmental organizations and other civil society organizations must be willing to work with schools, e.g., by having accessible teaching plans or supporting schools when they approach them.

Conclusions and implications
Our interpretation is positive more than critical: we are preparing development work with early childhood, compulsory, and secondary schools so we need back-up resources for the curricula. If seen from a more critical standpoint we argue that the Icelandic government needs to develop a more overt approach, perhaps a special curriculum manual, treating education for sustainable development as a subject matter or a topic for integration. Some of the substance needed for school work is though there in the various curricula and school texts.

References

The silence of innovation education in Icelandic science classes
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Innovation and the capacity to innovate are acknowledged as important traits in modern societies and supported by Icelandic economic and social policy (Office of the Prime Minister, 2007). Innovation education (IE) in the Icelandic curriculum has similarities to technology education in other countries, especially in Australia (Williams, 2006) but has not yet taken root. This paper reports on an examination of innovation education within science lessons in Icelandic compulsory schools. Bernstein’s pedagogical code is used to understand the development of innovation education or lack of it in science. Understanding different discourses and possible contradictions may help to clarify the potential innovation education has for developing science education.

Innovation education
Innovation education has been defined as follows: “Innovation education involves inventing new objects, redesigning things that already exist and building for change to enhance and improve the conditions of social life. It encourages children and young people to look carefully and critically at the material world that surrounds them. It teaches, through active engagement, that the material world has been made by people and can be altered, changed and improved. It develops critical thinking and practical skills in design and technology and in marketing and enterprise.”¹ In innovation education student autonomy is highly respected and the teacher is a facilitator whose role is to assist the student in the decision making process (Howard & Thorsteinsson, 2003). The student has more control in innovation education lessons than in traditional lessons (Gunnarsdóttir, 2001; Jónsdóttir, 2005).

Innovation education started to appear in Icelandic compulsory schools around 1990. In 1999 it was part of the curriculum for compulsory schools and was placed in the curriculum for Information and Technology Education (Aðalnámskrá grunnskóla, 1999a) without a time allocation and is called Innovation and practical use of knowledge. The science curriculum for compulsory schools (Aðalnámskrá grunnskóla, 1999b) is open to an IE approach though the word innovation is never used. In the sections of the science curriculum on the nature and role of science and on methods

¹ A definition of Innovation Education, by Dr. Catherine Burke (Leeds University) when introducing the subject to members on a discussion list on the internet about Innovation Education.
and skills we find terms such as *initiative, critical thought, independence* and *responsibility*. There is also a clear emphasis in the science curriculum on practical knowledge and skills, integration of subjects, student choice and importance of transferability of knowledge to everyday life. In other countries innovation or technology education are linked to science education. In Manitoba, Canada science as inquiry and technology as design are closely linked (Science. Manitoba Curriculum Framework of Outcomes, 2007).

This study asks the following question: Where is innovation education located within science teaching in Icelandic compulsory schools? We would like to know whether official discourse on science, technology and innovation is reflected in school practice.

**Bernstein's pedagogic code**

Bernstein's analytical framework has been used to understand what happens when knowledge is relocated from the field where it is originally produced into the field of education (Bernstein, 2000). His framework includes concepts about the *regulative discourse*, the *instructional discourse* and *classification and framing*. Classification refers to relations between categories, for example, between school disciplines or between agents, such as teachers and learners. School subjects can be insulated from one another, and may lose their identity if the insulation is broken. Strong or weak classification gives rise to different kinds of spaces between categories. Framing refers to controls on communication in pedagogic relations, for example, relations between transmitters and acquirers. Framing is about who controls what and in curricular terms this can mean control of the selection of material, sequencing, pacing and criteria of knowledge. Strong framing means the teacher has explicit control over these aspects of the curriculum (Bernstein, 2000; Chien & Wallace, 2004). Framing refers to the controls on the *instructional discourse*, that is who selects what is to be learned, the order in which it is to be acquired and how it is to be evaluated. The *regulative discourse* underlies what is done in schools; it regulates the social order of what is transmitted and refers to conduct, character and manner. The *instructional discourse* is how things are actually done in schools.

The instructional discourse is embedded in the regulative discourse (Bernstein, 2000), thus interventions, such as new curricula, may or may not succeed according to the extent to which the instructional discourse is aligned with the regulative. Individuals must possess recognition and realization rules so that they can recognize the phenomenon and then act accordingly. If the teacher or students do not possess adequate recognition rules of these power structures then inappropriate methods of instruction may be selected (Chien & Wallace, 2004).

**Methods**

The empirical approach of this paper draws on current research on the science curriculum in Icelandic schools in the project *Intentions and reality* (2005-2007) carried out in Icelandic schools with a grant from the Research Fund of Iceland. The *Intentions and reality* (IR) study involves 19 schools in five selected local communities with data from 105 teachers (Vilji og veruleiki, 2008). This work has been undertaken by pairs of researchers including the authors, from a team of twelve, during autumn 2006 and spring 2007.

A mixed methods approach was used in data-gathering. Actual and preferred versions of school science were studied through on-line self-evaluation by teachers of science in the selected schools using a questionnaire about science on one hand and on innovation education on the other (Lewthwaite, 2005). Of the 105 teachers that answered the science questionnaire only 60 chose to answer the IE questionnaire as the others thought that they did not have enough knowledge to answer it. Descriptions of school science and innovation education were collected from on-site visits. Transcriptions include interviews with science teachers, older learners and administrators. Some classroom observations were undertaken in most schools. The texts of selected written documents in the policy areas of science, technology, innovation and education from 1999 and onwards were analyzed.

**Results**

Classroom observations and interviews with students and science teachers showed that innovation education is uncommon in these schools in general and in science lessons. Principals of the schools are usually positive or neutral towards innovation education, but many do not see it as a task needing special attention. It was usually acknowledged that teachers knew little about innovation education with a few exceptions. The answers to the questionnaire on innovation education show that teachers would like IE to have more status in schools and that it has generally a low profile. The students in the interviews expressed a wish for more experiments and field work in science and the teachers are positive towards such approaches, but say they are pressed for time to cover the teaching materials and prepare students for national exams at the end of the 10th grade.

One of the schools in the sample currently offers innovation education as a special subject for one age group (10 year olds). In some cases the methodology of innovation education was detected in the school work, without the teachers knowing that they were acting in the innovation education spirit. Within science lessons innovation education is rarely used but was detected in few incidents. Innovation education was traced back some years in one school as an independent subject, but had disappeared as it required extra time and additional resources.
Conclusions and implications
The regulative discourse of society and the economy seems to be supportive of innovation education approaches, expects innovation in society and praises it as a valuable source of wealth and improvement in science and living. The translation of the regulative discourse into schools, however, does not manage to create a holistic IE instructional discourse in action. The discourse of innovation education in schools is hesitant, limited and vague or non-existent in science teaching at the compulsory level. It seems that the regulative discourse of the school has the better of the external supportive discourse of innovation.

Integration of the external and school regulative discourses are needed. The external discourse shows what is wanted but does not help schools with bringing innovation education into science lessons. The discourse of the school demands conduct and manner and criteria of knowledge that are often in opposition with innovation education.

Innovation education has a weak classification as it can be incorporated into any school subject. It also has weak framing with recognition and realization rules which challenge the typical practice of both teachers and students. In IE the students are given more autonomy than in traditional subjects where the teacher usually has clear power and control. To integrate these discourses in school practice, a mixed pedagogic practice of weak and strong classification and framing may be needed (Morais, 2002) which would open up the possibilities of using innovation education in science. In order to make such pedagogy work, the teachers and students must acquire recognition and realization rules that make the activity of innovation education in science possible. The students in the research want more hands-on experience in science and the teachers admit the importance of such work but the regulative discourse in lower secondary school of the national exams and of covering the “material” translates into an instructional discourse that has the opposite effect (Sigthorsson, 2007).

If IE is to be used in school science it must be introduced to science teacher students, in-service teachers and administrators in Icelandic schools so that schools have opportunities to acquire the necessary recognition and realization rules necessary for implementation.

References
Elevers sätt att hantera naturvetenskapen - några fallbeskrivningar med fokus på världsbild
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Bakgrund och syfte


Metod och urval

Resultat

Figur 1 Antal konflikter för 30 påståenden för eleverna i den undersökte gruppen
(se också Hansson & Lindahl, 2007).
Reflecting on the science curriculum

Vi har tidigare studerat elever som kategoriserats som att de har god förmåga i relation till Nv/Te-studier (Hansson & Lindahl, 2007). Det generella mönstret bland dessa elever är att de som valt Nv/Te ger uttryck för mindre skillnader (färre konflikter) mellan den egna världsbilden och den de förknippar med naturvetenskapen, än elever som valt andra studieinriktningar.


Slutsatser och implikationer


References


Dealing with the democratic aspects in science education
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Background, aims and framework

Teachers’ main tasks can be summarized in the form of an overarching, two-part assignment: to present subject matter and to foster independent, democratic members of society. This is sometimes called “the double assignment”, comprising a subject matter (or knowledge) assignment and a democracy assignment. I see the relationship between scientific subject matter and democracy in dialectical terms. On the surface, the concepts might appear to contradict one another. However, similar to other conceptual pairs such as theory–practice, body–soul, individual–society and humankind–nature, they are united and mutually dependent by virtue of an inner relationship (Israel, 1980). I refer to Hegel’s dialectical view that involves striving to understand the commonalities among apparent opposites; my goal is to highlight the integrating whole by emphasizing the subject matter–democracy relationship in science education.

You could say that the subject matter task is in itself a democracy task, seeing that pupils who understand the subject matter of their education are better equipped to manage in their daily lives and to take an active part in democratic decisions. The democratic assignment is, however, about much more – it is about using democratic forms and communicative interaction with others to foster attitudes that are in line with the fundamental values of society.

In my work as a teacher educator, for three years I had the opportunity to meet all of Växjö University’s student teachers during their first semester of study. During a course in sustainable development, the students were reading the book Naturvetenskap som allmänbildning [The Natural Sciences as General Education] (Sjöberg, 2000). The author argues that knowledge in science is needed for democratic reasons.

The student teachers were then asked to write down their reflections on their own view of the need for scientific literacy. The texts reflected their experiences of what science education has been like, but also their hopes about what it could be like in the future.

An analysis of the texts shows that for many of the student teachers, science education was boring and outdated. For this reason they do not care for further studies in the natural sciences. For these students, it was not enough to be able to explain how things work in a scientifically or technically correct manner – which they believe that educational practice has focused on so far. They did not become engaged. Many of them feel that they have not been trained to argue, discuss, or take a stance because most topics, particularly within physics and chemistry, are already “proven and established.” The argument that scientific literacy and science education contribute to the democratic development of individuals and society seems unfamiliar to the students. Many of them describe the opposite situation, that is, that more than any other subject, science education is characterized by authoritarian content and methods. Nor have they really understood the legitimacy of the natural sciences in schools. The teacher students wish for a type of science education in which communication, ethical and moral reasoning, and existential and emotional issues are included. These experiences of student teachers became the starting point for my work.

The purpose of my presentation is to highlight the relationship between teachers’ subject-matter and democracy assignments, and to show how dialogue-oriented educational efforts may be used to integrate both assignments in science education.

I deal with the following questions:
• How can the subject-matter and democracy assignments be united in science education?
• How can dialogue in education help prepare pre-service teachers to better manage the dual responsibility to teach subject matter and foster democratic citizens?

The idea that dialogue and communication are important for learning subject matter and for democratic development has compelled me to combine democracy theory in the form of the deliberative dialogue model with theories about learning, communication and socialization. My interpretation of the term “socialization” is not limited to order, subordination and adaptation in relation to a given system (for example, society or the schools), in which normative frameworks specify what is correct, right, and morally acceptable behaviour within the system. In education, socialization must involve the ability and willingness to show consideration for others outside one’s own given framework, according to the principles of “Enlightened understanding” (Dahl, 1989).

Conclusions and implications

Based on research on the importance of dialogue for learning subject matter and for democratic development, I propose dialogue-based efforts to help bridge the gap between subject matter and democracy in science education. By democracy, I mainly refer to deliberative processes in which the participants – in mutual communication – test the tenability of each other’s arguments seen from a universal perspective (Benhabib, 2002; Englund, 2006; Gutmann &
Gutmann, A., & Thompson, D. F. (1996). The idea of the importance of democratic dialogue for both learning and democracy implies that such dialogue can be seen as an opportunity to integrate the subject-matter and democracy assignments in teaching practice. The philosophical aspect of my argument rests on the idea that dialogue can be seen in part as a democratic goal in itself, and in part as a method for achieving learning objectives within a given subject. Because deliberative discussions require a certain knowledge of subject matter, I believe that the combination offers possibilities for both scientific and democratic development.

I also argue that student teachers should practice this type of integrative effort within the framework of the subject didactics component of their teacher training. For this reason I highlight the educational possibilities inherent in deliberative discussions about authentic or fictitious "socio-scientific issues" (Kolstø, 2001; Ratcliffe & Grace, 2003; Sadler & Donnelly, 2006) in teacher training. "Socio-scientific issues" are questions in which the problems involve scientific facts as well as sociological (normative) and subjective value aspects.

While I do not subscribe to the idea of a universal method, I do believe that teaching should be varied in order to offer different pathways to learning. One possible pathway to explore is deliberative discussions, in which pupils and even pre-service science teachers in training are given opportunities to improve their argumentation skills, their ability to take a stance, and to develop democratic skills via discussions of complex issues related to the natural sciences. Deliberative discussions can provide the opportunity to change perspectives, with an eye toward pedagogic discourse in science education, and with the goal to unite the dual assignment – knowledge of subject matter and democratic development. During their didactics training, student teachers can, for example, plan, carry out and evaluate discussion-based efforts.

However, the idea of deliberative discussions must also be critically evaluated. It is a relatively controlled procedure, which may seem rather dubious when seen from the perspective of democratic freedom. For example, the participants must agree upon the rules of order for the discussions as well as agree to follow them. To this end, they must treat each participant's argument with respect, tolerance and sensitivity. Those who engage in a deliberative discussion must also be able to present a common ground, a form of consensus, even if it can be a question of a temporary agreement. Critics of this consensus-oriented focus point out that the explicit aim to reach an agreement in a discussion can be a hindrance to critical argumentation, and thus impede the discussion. Another viewpoint is that the unavoidable power structures between different pupils – and between teachers and pupils – render genuinely deliberative discussions impossible. Additionally, the relatively out-of-the-way role of the teacher in deliberative discussions has also been questioned. In this case, I agree with Englund's (2006) view that teachers certainly must not abdicate from their actual (subject-matter) and formal authority. When using deliberative discussions in teaching, the traditional tasks of planning and leading classroom work and answering pupils' questions still remain. However, through their choice of material and methods, teachers – together with their pupils – can create the conditions for a "discursive situation" in which the participants agree about the guidelines of mutual respect and a willingness to understand (Englund, 2006).

The increased use of deliberative discussions in science education would be somewhat time consuming. However, could reducing the time devoted to other elements be counterbalanced by qualitative improvements through the discussions? It is fully conceivable that discussing complex and topical "socio-scientific issues" could increase interest in science. Discussion-based teaching can therefore be an example of one of the various changes that Osborne and Dillon (2008) see as necessary in order to reverse the trend of declining recruitments to natural science education.

The potential of deliberative discussions must be evaluated against the background of the challenges I have described here. The evaluation should offer the freedom to deviate from certain aspects of the ideal behind deliberative discussions, in order to evaluate their potential in classroom situations.

The daunting and delicate task of evaluating whether or not deliberative discussions really do contribute to both democratic development and in-depth knowledge in science remains to be examined empirically. I will present some preliminary results from an empirical study including three classes in upper secondary school, studying Nature and Environment A [Naturkunskap A]. The students were discussing two "socio-scientific issues" concerning the greenhouse effect, using the guidelines from the teaching scenario presented by Gustafsson (2007, p. 115-116). In this study, the aim is to evaluate what is said and to interpret what is left unsaid, as well as how the discussions contribute to pupils' scientific literacy and their democratic development. How scientific knowledge is used and how democracy aspects are expressed in the discussions are areas of particular interest.

References
Gustafsson, B. (2007). Naturvetenskaplig undervisning och det dubbla uppdraget. NorDiNa, 3(2), 107-120.
The place of liberal values in science teacher education

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Introduction, background, aims and framework

This paper is a result of reflection on literature studies and on my personal experience of working in science teacher education in Sweden and other countries over the last decade. The issue of values arises naturally in any curriculum project. Recently, explicit discussion on this topic reappeared in the field of science education with the publication of the book “The re-emergence of values in science education” edited by Debbie Corrigan, Justin Dillon and Richard Gunstone (2007).

The main purpose of this paper is to argue that modern science education should provide space for students to pursue liberal as well as humanistic educational values, directed towards general intellectual enlargement and refinement; not narrowly restricted to the requirements of technical or professional training. Humanistic values aim to animate student’s self-identities, their future contributions to society as citizens, and their interest in making personal utilitarian meaning of scientific and technological knowledge (Aikenhead, 2006). The readiness of the teacher to meet the students’ pursuit of liberal education in the science classroom is also problematised.

Swedish curricula emphasise the active agency of learners already at the lower school grades. The individual science teacher has the freedom (within the frame of his or her own competence and values) to prioritise what subject knowledge and values to focus on, what messages within and about science to communicate and how to motivate students.

In this paper a complementarity approach for the analysis of value-work in education is used as a methodological principle. This approach is based on the complementarity principle suggested by Nils Bohr in 1927. According to Bohr, we have to accept that a micro-world object can reveal different properties in different circumstances that can be explained by rather incompatible theories. Bohr suggested the possibility of using this principle in other fields of science than physics (Ben-Dov, 1995). Such an attempt is made in this paper.

Liberal science education

Historically, studying science was a part of liberal education. According to the Webster Dictionary definition it is education that enlarges and disciplines the mind and makes it master of its own powers, irrespective of the particular business or profession one may follow (http://www.webster-dictionary.net). Liberal education assumes that students engage in learning for the sake of enjoyment of learning and knowing. The ideals of liberal education can be seen in the OECD forum curriculum recommendations for increasing interest, motivation and competence in science studies amongst students (OECD, 2006). These include among others:

- Transmitting the excitement of science from the teacher to the student.
- Exposing students to the joy of discovery.

These recommendations emphasise liberal values of learning science just for the joy of learning it. Some students might experience the excitement of discovering scientific explanations of the structure of the Universe, learning about quarks or global phenomena in the Earth and this could be enough for them to be highly motivated to study science. However, showing the students the possibility of loving science just for its beauty, logic and intellectual challenges no longer seems to be common among teachers. The OECD (2006) attributes this problem to the fact that many teachers themselves do not have a sufficient level of comfort and confidence about science and maths.

Most small children are curious about physical phenomena and their explanations. They get personal satisfaction from knowing how things happen. Many of them like to think hard and can ‘work hard’ in the learning process. However, this potential for intellectual work and patience in learning disappears if not stimulated and practiced. As physical activities shape the body, intellectual activities shape the mind. Learning science demands hard activity by the mind and can provide real intellectual gratification in the form of understanding. But, it is not possible for everybody to achieve success...
in science, in the same way that not everybody can succeed in sports or music.

Teachers have limited possibilities (and abilities) to provide appropriate (in Vygotsky’s terms of the zone of proximal development) intellectual challenges for every student in the class. But the teacher can trigger the student’s interest. Similar situations exist in other fields of human activity. For a long time, Sweden has been successful in “producing” famous athletes and musicians. A basis for succeeding in these fields is laid down by many dedicated teachers in compulsory schools and developed further in specialised (state and municipality supported) sport or music institutions (formal and informal).

Similarly, the ordinary school education cannot lay the groundwork for being a good scientist for every student. At best, teachers can challenge and generate an interest in “pure” science studies for some students, but not all. Greater possibilities to prepare for future sport, music or science careers (and to give young people the possibility of experiencing the joy of the corresponding activity) exist in specialised schools/classes or other specialised institutions like sports clubs, music schools, science clubs, etc. In some schools, enthusiastic teachers can engage many students in science studies (for example, in Swedish national physics competitions teams from the same schools usually take leading positions many years consecutively). However, broad and stable success cannot be assured without the work of specialised institutions supported by the state, as in the case of music and sport.

It is also possible to make a remark here about the role of parents in discovering and triggering children’s interest in different activities. Apparently, adults have less chance and possibility to realize and develop a child’s interest in academic studies and “solving science puzzles” in the home environment than they have to inspire their music or sport activities. The role of the science teacher in awakening and stimulating the child’s interest in science cannot be overemphasised.

Many extracurricular activities in existing science museums and centres in Sweden are organised under the banner “science is fun!” Curriculum innovations also lead teachers to work in the direction of making learning science fun and doing science activities as an exciting leisure activity. However, Swedish curriculum LPO94 also states that “Education should be adapted to each pupil’s circumstances and needs. Based on the pupils’ background, earlier experiences, language, and knowledge, it should promote the pupils’ further learning and acquisition of knowledge” (Skolverket, 2006). Unfortunately, striving to support “weak” students, schools often forget the needs of the children who are genuinely interested in science. Those children who see intellectual achievement as a goal in itself and have internal motivation (self-challenge) to study tough science.

Science teacher education provides prospective teachers with limited skills to develop students’ abstract and logical thinking. Prospective teachers have low interest in developing methods of advancing students’ skills of abstract-theoretical thinking in science education (as it is reflected by the content of their examination projects). This can partly reproduce the absence of teacher educators’ research interest in this matter (as it is reflected in the applications to the Educational Committee of the Swedish Research council - UVK).

Conclusions and implications

It appears that in Swedish teacher education, prospective science teachers are not trained to teach students who are interested in science, but rather to motivate those who are not interested in it to study science. If a student is indifferent to technical, social and other everyday applications of science, but wants to satisfy his/her own curiosity in scientific understanding of the world and enjoys solving “science puzzles” many teachers do not have enough competence to help such students. They are not trained for that and may not even see the problem. Focusing on “weak” students, teachers tend to miss “strong” ones.

The challenge of finding a place for liberal as well as humanistic values in science education is not easy to meet. Teacher education also has limited opportunities to provide a deep knowledge of science to students without extra economic support from the government. Teaching small groups of students (because of low enrolment to science teacher education) is not economically feasible if the number of contact hours is not reduced. As the OECD (2006) points out, “governments and relevant institutions should provide adequate resources for teacher training and classroom activities. Flexible, more attractive curriculum structures with updated science and technology content should be devised”.

Flexibility in curriculum design is important but of no less importance is the teacher’s knowledge and skills in how to satisfy the cognitive needs of “weak” students as well as the “strong” ones. Here, the principle of complementarity also works, nobody knows when practical relevance (or showing the humanistic side of science) and when abstract knowledge (or cognitive challenge) can trigger student enthusiasm for science. In different circumstances and for different people both of these curricular elements (set of values) can be vital.

The approach of complementarity rejects clear-cut answers to existing problems. For example, science education for everyday life (Aikenhead, 2006) cannot be the only solution to attracting students to science studies. The modern science education curriculum should provide space for students to pursue humanistic as well as liberal education values.
**Students’ early experiences of biodiversity and education for a sustainable future**

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### Background, aims and framework

During the last decades, humankind has become increasingly aware that it will have to make important environmental decisions which will demand substantive knowledge of critical ecological phenomena such as biodiversity. We argue that it is therefore important that teaching at school helps students to develop an understanding of these phenomena and prepares them for the future.

Having spent a lot of time in the natural environment with students of different ages, we have experienced a great curiosity and fascination among young people about the variety of life as a part of the biodiversity they experience around them. As teachers, we have also seen that there is a great variation among students concerning their ability to discern biodiversity in nature. With these students’ experiences of biodiversity as starting points, it is possible to help them develop an understanding and ability to apply concepts of biodiversity. Such a teaching strategy can make an important contribution to education for sustainable development (UNESCO, 2004).

Biodiversity changes to a certain degree because of our influence on the natural environment. Identification of such changes in biodiversity can give us important insights as to the status of an ecosystem. In order to help students to read nature and develop an ability to discern biodiversity in different contexts and hopefully also to discern changes, we need to investigate how they experience biodiversity and how they discern different components of the ecosystems. The first author found during a longitudinal study of students’ understanding of ecological processes that episodes in childhood can be of great importance in their future learning about scientific phenomena (Helldén, 2005). Other researchers like Hutchinson (1998) argue that middle childhood is a crucial period for the emergence of a child’s working theory of the world. Hutchinson says that it is important to engage with children’s ideas about nature and environment because certain values and beliefs may be rooted in this sensitive period of development. It would be important to investigate the abilities of students to discern the variation of organisms in different ecosystems and what kind of early experiences of biodiversity they have. Therefore, we carried out an interview-based investigation into how students described the diversity of life. The present study was carried out from a perspective that learning involves both social interaction and individual construction of knowledge.

The aims of the research project presented in this paper were:

- to study how students might discern biodiversity in different ecosystems
- to investigate the importance of previous everyday experiences for their ability to talk about organisms
- to discuss the results from this study in relation to education for a sustainable development.

### Methods and samples

In order to investigate students’ experience of biodiversity in different ecosystems, we interviewed fifteen 10-12 year old students individually about what organisms they saw on four different occasions:

1. Standing in front of a meadow surrounded by trees and bushes
2. Looking at a sample of freshwater organisms from a pond
3. Standing at a slope along a small stream with a lot of flowers
4. Looking at a sample of litter with soil invertebrates from a forest.

In our analysis, we studied the students’ ability to discern organisms, and how they described the organisms. The students were also asked how they could recognise the organisms.

We also took notes and audio-recorded some student discussions during bird watching in a wetland. All the students in this study belonged to the same class of a primary comprehensive school, situated in the countryside near a small town.
in Sweden. The students comprised an integrated class in grades 3 (10y), 4 (11y) and 5 (12y). They had had a monthly nature walk since they were six years old. The interviews were audio-taped and transcribed verbatim.

During the analysis of the interviews we found interesting features in the students’ descriptions of organisms. We wanted to know more about these features. A longitudinal study of students’ understanding of ecological processes showed that students’ consideration of prior interviews with them could contribute to the interpretation of these interviews (Helldén, 2005). In order to be able to carry out a more complete analysis of the interviews, we interviewed students in the present research project two years after their first interview. After they had listened to our previous interviews with them, we asked them to comment on what they had said two years earlier. Ausubel’s theory of meaningful learning had important implications for the analysis of the interview data (Novak, 1998).

**Results**

We analysed the transcripts of interviews with the students concerning what plants or animals they discerned in the four cases. We also investigated how they referred to experiences from everyday life when they talked about the plants and animals.

One group of seven students had a good ability to discern organisms on the four occasions. These students did not always know the names of some of the organisms but willingly used colours and other characteristic features in their descriptions. When they described the plants in a meadow, they could make comments about what the plants looked like and their role in everyday life.

Students in this group were able to make comments on the characteristics of the invertebrates in the litter and freshwater sample. The students were less familiar with the organisms in the freshwater sample. Many students in this group referred to terrestrial organisms when we asked them to describe what they saw. They often linked their descriptions spontaneously to what they had experienced in everyday life. Episodes they had experienced together with family members seem to be of great importance for the students’ ability to identify plants and animals. The students in this group more often expressed feelings of admiration or annoyance when they talked about different organisms than students in the following group.

Another group of eight students showed only a weak ability to recognise organisms in the four cases. Even if some of the students recognised organisms, they did not talk about characteristic features of the plants and animals. Unlike the previous group of students, their descriptions did not contain such detailed and colourful descriptions. In some cases, these students referred to terrestrial organisms when they talked about organisms in the freshwater sample. They seldom referred to personal, everyday-life experiences when they talked about organisms. This group of students used relatively few words when they talked about what they saw in natural environments or in the samples.

There were no differences between the two groups concerning their ability to identify birds during the wetland excursion, but students in the first group had a greater ability to describe and refer to birds they already knew.

During the second interviews, the students listened to their initial comments from two years before. We asked the students to make comments on their answers and why they said what they had said. They referred with joy and pleasure to concrete early experiences they had had in a garden or in the woods together with family members. They emphasised the importance of the short nature walks their class had taken with their teacher in early primary schooling. During such events, the students were able to identify and talk about some key organisms that later on could be referred back to when they saw other organisms in natural environments.

**Conclusions and implications**

In order to give students a preparedness to discern changes in the natural environment in the future, we need to develop their ability to discern biodiversity. Therefore this is an important part of education for a sustainable future (UNESCO, 2004). The present study has shown that early experiences of identification of some key plants and animals are important, especially if such experiences are connected to episodes in everyday life. Pleasure and joy as well as pride at being able to identify organisms are important parts of such experiences. Not only thinking but also feeling and acting are important components in education (Novak, 1998). The students can then develop their ability to discern biodiversity by attaching the identity of newly-encountered organisms to those they already know. We assume that this is what Jerome Bruner (1996) meant when he argued that the first objective of learning, above and beyond the pleasure it may give, is that it should serve us in the future. Such strategy might characterise education for the future by helping student to discern biodiversity changes in the natural environment.
References


Planning science instruction: From insight to learning to pedagogical practices

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Synopses: The goal of scientific and technological literacy

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The goal of scientific and technological literacy
“Hvor langt er PISA fra Danmark?” Delresultater fra et projekt til validering af PISA 2006 i en dans kontekst

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Baggrund, mål og kontekst


VAP-projektet er formuleret som en række delprojekter, hvoraf nogle endnu er uafsluttede. De enkelte delprojekter har selvstændige forskningsspørgsmål og forskelligt forskningsdesign. Nedenfor beskrives de tre delprojekter, som er relevante for denne præsentation.

Metoder og samples
1. Hvad vil PISA måle - og i hvilken udstrækning er det foreneligt med den intenderede danske naturfagsundervisning?
   På et plan er her tale om en undersøgelse af PISA’s formelle relevans for DK. Konkret og metodisk handler det om at sammenligne PISA’s teoretiske framework (OECD, 2006) med intenderede læreplaner og såkaldte Fælles Mål for undervisningen i fagene fysik/kemi, biologi og geografi. Sammenligningen omfatter såvel kompetencemål som indholdskategorier og afdækker både hvilke nationale prioriteringer PISA faktisk indfanger - og hvilke PISA udelader.

2. Er PISA’s målemetode rimelig og dækkende i.f.t. den evalueringsspraksis danske elever møder i naturfagsundervisningen?
   En nærliggende hypotese kunne her være, at danske elever underpræsterer i PISA, fordi de ikke er fortrolige med en sådan type testning i naturfag. I DK har folkeskolens afsluttende prøve i fysik/kemi traditionelt været mundtlig og praktisk/performance-orienteret.

   Evalueringsspraksis i naturfagsundervisningen er her undersøgt via en elektronisk survey-undersøgelse omfattende et repræsentativt sample af 1159 naturfagslærere. Det endelige spørgeskema blev udarbejdet på basis af forudgående lærerinterviews og efter pilottestning.

3. Er PISA-resultaterne et validt udtryk for, hvad danske elever faktisk kan indenfor det testede område?

   VAP-delundersøgelsen er her designet, så den muliggør en forholden sig til såvel det generelle gyldighedssprøgsmål som til omtalte hypotese(r).

   Forud for 2006-testen havde vi adgang til de pilotede engelske versioner af opgaverne, samt deres fordeling på opgavehæfeter (”booklets”). Herudfra valgte vi 3 opgaver, som fulgtes ad i et antal hæfeter - samtidig med at de indholdsmaessigt udsendte såvel de relevante fag (fysik/kemi, geografi, biologi), som PISA-kontekster og kompetencer. Den ene opgave (”Sunscreens”) var yderligere udvalgt, fordi den illustrerede et forsøg, som nemt og direkte kunne gennemføres af elever i praksis.
Vi fik adgang til et stratificeret sample på 120 elever på 30 sjællandske skoler, som alle havde besvaret de udvalgte PISA2006-opgaver. Disse blev gentestet 2-8 uger efter - på de tre udvalgte opgaver, samt et antal uforandrede opgaver (af grunde som fremgår nedenfor).

Valideringsdesignet: Grundlæggende er der tale om et test-gentest-design. ”Testen” er her (et hjørne af) PISA 2006, hvor det danske PISA-konsortium velvilligt har givet os adgang til de relevante rå elevscorer. ”Gentestningen” af den enkelte elev varede 2 timer og bestod af følgende tre komponenter:

- **PISA-tro gentesning:** et antal originale opgaver besvares på ny i det originale PISA-besvarelsesformat. (individuelt, skriftligt, samme tidsramme). Dermed fås mulighed for at korrigere for, at elevpræstationerne forbedres som følge af simpel gentagelse (direkte genkaldelse m.m.)
- **Individuelle interviews med eleverne omkring to originale PISA-opgaver (varighed 30 min.):** Interviewene blev gennemført af specielt trænede assistenter og med udgangspunkt i en semi-struktureret interviewprotokol. De video-filmede interviews skulle efter vanlig standard give det bedst mulige indblik i elevernes reelle forståelse af opgaverne.

**Resultater**

*Ad 1.* Analysen viser, at:

- PISA’s videnskontekster er særdeles relevante for DK.
- PISA’s kompetencemål er i rimelig grad relevante for DK, om end evidens-drevet argumentation og logisk-deduktive processer ikke findes med samme centrale vægtning i Fælles Mål for naturfagene.
- Vægtningen af fagområder i PISA-testen afviger fra de majorske fagområder i den danske folkeskole. PISA vægter biologi og geografi forholdsvis højere, end så fuldstændig som det er i DK mest centrale naturfag.
- Alligevel er der indholdsstærkt stort over afslutning mellem PISA-science-testens fagområder og målbeskrivelserne for biologi og geografi. Det er vigtigt at konkludere definitivt på, at fysik/kemi’s evne til at ”dække” PISA-området **Physical Systems.**
- Viden om naturvidenskabelig viden indgår i folkeskolens mål om **Arbejdsmåder og tankegange,** men med mindre vægt end i PISA.
- Danske læreplaner vægter ”sammenhænge”, ”væsentlige træk”, ”perspektivering” og en mere ”helhedsorienteret” vægt end det ambitionen med PISA.
- **Praktisk-ekspertilment ærbe vægtes høj i DK** - og er udeladt i PISA-frameworket.
- Der er forskelle i vægtningen og karakteren af de affektive aspekter i PISA-frameworket og i de danske læreplaner.


*Ad 3.* I skrivende stund er analyserne af PISA-testens validitet ikke tilendebragt. Vi forventer imidlertid at kunne fremlægge hovedresultaterne herfra på **Symposium 9.** Der er imidlertid skrevet to specialer på baggrund af VAP-empirien, som viser materialets didaktiske potentiale. Disse vil blive omtalt.

**Konklusioner og perspektiver**

VAPs første delundersøgelse viser, at der er rimelig stor overensstemmelse mellem PISAs intentioner og de danske uddannelsesmål inden for naturfagene, men at der alligevel er vigtige forskelle i fagopfattelse og vægtning. Vi anser dog en modsætning mellem intenderede kompetencemål og de organisationer med opgaver i PISA, som det er værd at undersøge.

VAPs anden delundersøgelse viser at danske læreres daglige evalueringspraksis i høj grad erforenelig med PISAs testformat.
The goal of scientific and technological literacy

VAPs tredje delundersøgelse vil vise i hvilket omfang PISA-testformatet giver samme resultater som et mere dialogisk orienteret testformat.

VAP-undersøgelsen tematiserer overordnet set nogle grundlæggende forhold i naturfagsundervisning, nemlig hvad der forstås ved viden og hvorledes denne viden kan evalueres. Så uanset hvilke resultater, der viser sig, vil de bidrage til en bedre vurdering af PISA-testens gyldighedsområde og dermed dens ønskværdige uddannelsespolitiske rækkevidde.

References

Science for life – development of a conceptual framework for modelling socio-scientific cases
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This paper describes the first step of a research project aiming at investigating how pupils and teachers develop interest and knowledge in science when working with socio-scientific issues.

Background, aims and framework
There is need to develop science education in order to develop pupil interest and knowledge in science (Aikenhead, 2006). One way is to bring in a humanistic perspective (Aikenhead, 2006) and to focus more on scientific literacy than science literacy (Roberts, 2007). Ratcliffe & Grace (2003) have characterized socio-scientific issues (SSI), with a basis in science, as important for society. They involve forming opinions, are frequently media-reported, involve values and ethical reasoning, may require some understanding of probability and risks and there are no “right” answers.

In studies about SSI pupils have been working typically with an issue including a dilemma. They have been observed and/or interviewed and their written reports have been analysed (Aikenhead, 2007; Grace & Ratcliffe, 2002; Jiménez-Aleixandre & Pereiro-Munoz, 2002; Kolstø, 2001.). Aikenhead (2006) summarises in a research review that pupils working with SSI generally sought few scientific facts, weighing values more heavily than science. Lewis and Leach (2006) report that pupils need scientific knowledge, but they can engage in issues about gene technology with relatively modest science knowledge if the content is well designed and contextualised.

Another question deals with whether or not the pupils develop conceptual understanding in science when working with SSI. It seems that an issue with social relevance is more motivating to the students. However SSI are often complex and therefore more difficult to understand (Aikenhead, 2006). On the other hand motivation can overcome complexity and lead to greater achievement on traditional science tests (Sadler, 2004).

Research project
We need to gain more detailed knowledge about what features in content and organization affect the development of interest, knowledge and self-efficacy among the pupils. As reported above, most research concerning work with SSI in science does not particularly discuss characteristics of the content.

The aim of this evidence-based research project is to learn more about the importance that features of the actual case or issue, as well as factors in classroom work, have for the impact on student interest and learning. Another aim is to gain more detailed knowledge about teachers’ experiences with teaching SSI. We are interested in knowing more about the impact on teachers and students of particular features of issues.
The project is conducted in three steps. In step one, reported in this paper, a conceptual framework, consisting of six components, is developed and operationalized into a number of authentic cases for science in school. Aikenhead (2006) draws the conclusion that most work attempting to change school practice has failed as a result of problems arising when researchers try to transfer the success of one research project to a new context. Most studies are small-scale studies involving only a few volunteer science teachers to initiate the novel project. Therefore in step two we have a quantitative research approach. About 100 school classes in Sweden with approximately 1500 pupils worked with one or several cases during 2007 (data on how the task characteristics relate to students’ affective and cognitive experiences during work will be available spring 2008).

**Methods and samples**

The aim of this paper is to describe how a conceptual framework, which can be used as an analytical tool for understanding and constructing socio-scientific case development. The framework focuses on content and features of the SSI. It will be used as a tool for analyzing what components of the tasks are related to, and most influential on, interest and learning in work with socio-scientific issues in secondary school. The six components are chosen to reflect what we know from research literature about what might have an impact on interest and learning. It is possible to find variants within each component. For example SSI should be authentic but what importance does the specific authentic context have?

**Results**

The framework consists of a grid with the six components and the six cases. We will describe the model in detail and how it can be used for construction of cases and analyses of the work in school. Starting-point (authentic situation), school science subject, nature of scientific content, social content, use of scientific knowledge and level of conflict of interest.

### Components of the model

1. Starting-point (authentic situation), TV-programme, newspaper articles, personal homepage, a novel, the pupils’ family situation and the school canteen
2. School science subject: biology, chemistry, physics and technology
3. Nature of the scientific knowledge-base and evidence e.g. well agreed upon, contradictory reports
4. Social content e.g. economy, ethics, media
5. Use of scientific knowledge - decision-making, suggestions, critical scrutinizing, investigating
6. Level of conflict, the individual, the societal and the structural level

The six cases developed from the model are briefly described.

1. **You are what you eat?**
   Anna Skipper is the host of the Swedish version of the TV-production “You are what you eat”. In each programme a person with weight problems, usually overweight, gets advice about how to change lifestyle to get fit. The pupils’ mission is to scrutinize the advice given and to compare the information about food, exercise and health with other sources. The pupils make decisions about their personal life style. Teachers and pupils decide together how the result should be reported.

2. **Laser treatment and near sightedness**
   On a personal homepage Susi talks about how much she hates wearing glasses and that she finally has gone through laser treatment for her near sightedness. It cost lots of money and the costs are not covered by the social insurance system. The mission is to decide if it is worthwhile go through such a treatment and about who should pay – the individual – or society. Teachers and pupils decide together how the result should be reported.

3. **To hear or not to hear?**
   In an excerpt from the novel *Talk, talk* by T.S. Boyle, Dana who is deaf since birth and her hearing boyfriend Bridger discuss if a cochlea implant is a solution for Dana. She is very hesitant as she feels that hearing or not has to do with her identity. This is very difficult for Bridger to understand. The mission is to analyse different ways to judge this situation and to take out arguments for different views. We do not find it appropriate to encourage the pupils to have a personal opinion on what Dana should do. Teachers and pupils decide together how the result should be reported.

4. **Me, my family and global warming**
   The mission is to find ideas for how the pupils’ families can contribute to decreasing carbon dioxide emissions. The pupils start out by mapping the family’s need for transportation, what kind of motor-driven vehicles there are in the family, and how these are used. After that they test different alternatives considering ecological, scientific, economical and social aspects. The mission is to produce a realistic plan for how to decrease the carbon dioxide emissions of the family.

5. **Are mobiles hazardous?**
   Starting from two articles from the same newspaper – one saying that are no risks with mobiles and one saying that the risk for developing a brain tumour is considerable. The pupils should find out what information there is, how it is
provided and by whom. The mission is to make a decision about the consequences for their own use of a mobile and/or how they would choose when buying a new one. Teachers and pupils decide together how the result should be reported.

6. Climate-friendly food in school?
The mission is for class to check how food, served in the school canteen, affects the climate and if there are better alternatives to some examples of food. The mission is to suggest a change and to write a letter to the headmaster and ask him to consider.

References

Meaning making from a socio-scientific debate on gene modified food
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Background, aims and framework
According to Vygotsky, all learning originates in social situations. It is a process of internalization; a passage from meeting new concepts in social contexts to individual understanding of the concepts (Vygotsky, 1978, 2001). Learning science should, according to this, include meeting new scientific ideas, internalizing them and learning to apply them. Teaching science is, accordingly, a question of introducing scientific ideas and making them available for the students to internalize (Mortimer & Scott, 2003; Scott, Asoko & Leach, 2007). In addition, situations should be created, where students are given the opportunity to make use of their knowledge in new situations. During this process the teacher has to be aware of students’ existing notions of the concept in question, how the notions develop and how the students use their new knowledge during the lessons and take these as points of departure when developing a convincing scientific story for the students to grasp (Mortimer & Scott, 2003).

During the last decades science educators and others have become aware of the tension in science education between teaching in science, i.e. teaching science matters and the products and processes of science, and teaching about science, i.e. teaching science-related issues in which scientific knowledge is of importance (Roberts, 2007). Traditionally, science teaching has been rooted in the former, teaching scientific facts, but an increasing number of science educators are emphasizing the importance of using everyday and actual situations, preferably a controversy, where scientific knowledge is used as a point of departure in instruction (Millar & Osborne, 1998). The use of socio-scientific issues is one way of doing this, for instance through debates on controversies. This has become an increasingly important part of science instruction in many countries including Norway although there seem to be some barriers for science teachers to include this kind of activities in their teaching (Jimenez-Aleixandre, Rodrigues & Duschl, 2000; Mork, 2005b; Tal & Kedmi, 2006).

Socio-scientific debates are supposed to give students opportunities to develop their ability to use scientific evidence in new situations when making their arguments, as well as a chance to use and strengthen their factual knowledge about a certain scientific issue (e.g. Driver, Leach, Millar & Scott, 1996; Duschl & Osborne, 2002; Zohar & Nemet, 2002). The use of knowledge in new situations is a form of higher order thinking which potentially makes learning science a more challenging endeavour. Also, teachers may not be familiar with teaching science this way, and lack teaching repertoires for these kinds of activities (Duschl & Osborne, 2002; Mork, 2005a; Simon, Erduran & Osborne, 2006).
The analysis presented here takes its point of departure data from an instruction sequence built up around a role play debate on a socio-scientific issue, genetically modified food. Research questions asked in this particular analysis are

- Is there evidence for meaning making during the instruction sequence?
- How is meaning making framed and scaffolded during the instruction sequence?

**Methods and samples**

The data are from a Norwegian study called PISA+. This project is an in-depth classroom video study aimed at studying offered learning activities (actions) and experienced learning activities (meaning) in mathematics, science, language and arts classrooms. This particular analysis is of the meaning making of two students, aged 14, during an instruction sequence that includes a role play debate on gene modified food held in a mixed age group of students 13 to 15 years old from grade 8, 9 and 10 in lower secondary school. Prior to the debate the students had been introduced to the issue by working through a net based resource on www.viten.no. The debate was arranged as a TV debate. Some of the students played roles in the debate, and the rest of the group acted as audience. The teacher had a passive role during the debate. After the debate she summed up important points through a sequence of dialogical instruction. After the sequence two students were interviewed.

All parts of the instruction sequence were video-taped, including the student interview. The debate, the interview and the summing up were transcribed as were important parts of the teamwork in front of the computers. The instruction sequence is analysed when it comes to how factual knowledge develops during the sequence, how the teacher guides students in their meaning making and how the students make use of their knowledge in the debate and in the interview afterwards.

**Results**

The students interviewed make meaning of new information that comes up during the instruction sequence. Towards the end of the day they know how gene modification in an organism occurs. This knowledge exists, however, parallel to and at the same time as previous, alternative conceptions seen through the preparations in front of the computer. It seems that there is no conscious connection between the conceptions, and the students do not seem to reflect upon the fact that they use different explanations in different situations. During the debate students use sound arguments as well as arguments partly based on alternative conceptions. This might strengthen alternative conceptions held by other students. Most of the students use only one piece of information to support their claims.

The teacher listens to the students when guiding them, explains gene modification in different ways and does a very conscientious job. She focuses, however, almost solely on traditional factual knowledge rather than on how to use knowledge in new settings, e.g. in order to underline an argument during a debate. Neither the students nor the teacher comment much upon the art of debating when the debate is over.

**Conclusions and implications**

It seems like instruction sequences where socio-scientific issues and debates are used present teachers and students with challenges which they are not familiar. Teachers may not know how best to guide and evaluate students in the development and use of new knowledge when using these kinds of learning activities. Students are not explicitly trained to apply scientific knowledge in new situations. These challenges might make meaning making more difficult.

It seems as though the teacher lacks tools when it comes to teaching science through using socio-scientific issues. Usually, teacher experience is based upon teaching the products of science, e.g. what DNA is, and how genes are modified. This is important knowledge, and the students need it when discussing genetically modified food. The problem seems to be that the students get the knowledge all right, but they do not manage to use it properly in practical situations. This means that the gap between the factual knowledge and the practical use has yet to be bridged.

One way to do this is through making the gap explicit by talking about it. Another possibility could be to video-tape the lesson (debate) in question, and then comment upon situations where alternative conceptions are brought up or situations where knowledge is used in ways that can serve as models.

**References**


Background, aims and framework

In this paper, results from a study that aims to investigate on what basis pupils in an upper secondary school science programme form opinions on a socio-scientific issue will be presented. The issue of genetically modified plants was used as an example as it is a socio-scientific issue according to criteria set up by Ratcliffe and Grace (2003). The interest in this study is to illuminate what knowledge pupils need in order to feel confident in decision-making.

Some studies show that people with a sound knowledge base find it easier to express a decided view irrespective of opinion (Jallinoja & Aro, 2000). In a comparative study between pupils in upper secondary school in Great Britain and Taiwan, it was found that the British pupils who had had more teaching on genetic engineering and more opportunities to discuss generally were more positive about genetic engineering (Chen & Raffan, 1999). In these investigations there has been no specific investigation into what knowledge is important for decision-making. There are a number of studies showing that pupils' understanding of genetics, heredity and genetic engineering is weak (Lewis & Wood-Robinson, 2000; Wood-Robinson, 1994). However, Lewis and Leach (2006) report that those pupils can engage in issues about gene technology with relatively modest science knowledge if the teaching is well designed and contextualised. In a Swedish study it was found that pupils in upper secondary school often formed opinions on emotional reasons and that they were not critical of the sources of information (Kärrqvist, 1996).

Research questions

Are pupils' opinions on genetically modified organisms (GMOs) influenced by biology teaching?
What is important for the opinions the pupils hold and how does knowledge work together with other parameters such as values?

Methods and samples

In all 64 pupils in the science programme in three different upper secondary schools in Sweden participated in the study. The Swedish syllabi are goal-driven and not very detailed. There is much to be included in the biology courses and the time set aside for gene modifications in plants is generally short.

Data were collected by questionnaires and interviews. All the pupils answered one questionnaire at the beginning of the course and one at the end. Both questionnaires contained a scientific description of genetically modified tomatoes. The second questionnaire also included a description of genetically modified soy. The pupils gave their view on a number of statements by ticking boxes with different alternatives. They also got three open-ended questions in which they gave arguments for and against the described cases and also stated what arguments were most important for their personal decision. The reason for including the second case was to reveal if the pupils could distinguish between these two genetic engineering applications as the background is different. Two questions contained statements from a researcher and from Greenpeace's homepage (www.greenpeace.se). The pupils could tick boxes indicating agreement, disagreement or "I do not know".

The questionnaires also included open-ended questions to test the pupils' understanding of genetic concepts and some questions in which the pupils judged their own knowledge about some concepts in gene technology and some applications by ticking alternatives.

Eleven pupils were then chosen for interviews. In the interviews the pupils were asked to go into more depth in argumentation concerning GMOs. The interview started from a newspaper article discussing whether genetically
modified soy (cow fodder) should be imported. By discussing soy and other applications – golden rice and potatoes modified to produce only one kind of starch – the pupils expressed opinions and arguments about these. They were asked to explain, develop ideas, ask questions and react to different kinds of counter arguments. There were also questions about views on genetically modified animals and bacteria. Finally, the pupils were asked about the quotes from the researcher and Greenpeace. The interviews were performed with one pupil at a time and lasted for about 30 minutes. All interviews were tape-recorded and transcribed verbatim.

Analysis
For the closed (ticks) responses in the questionnaires simple statistics – percentage and means – was used. The open questions about arguments were simply categorised as factual, including values or/and risk assessment. Each response concerning understanding of genetic concepts and knowledge of GMO was marked with points 0, 1 or 2. The points were summed up.

In the interviews a number of themes were identified and coded. The themes were risks, assessing risks, trust in research, and knowledge about the procedure, doing something good, ambiguity, time perspective and feelings.

Results
There was a slighty more positive attitude towards gene-modified tomatoes after the courses. Men were more positive than women. The pupils who took biotechnology were in general more positive. No relationship was found between knowledge of basic genetics and opinion. Most of the pupils could express arguments for and against the applications but they based their own opinion on different arguments. The questionnaires showed that an important argument is how the pupils assessed risks. This was confirmed in the interviews. The pupils came back to the risks over and over again but they judged them differently. Depending on this judgement and/or how they trusted scientists they came to different opinions. Few had any idea of how the different applications are risk assessed or how scientists work. Some pupils who had performed their own experiments in biotechnology changed their opinion to being for as they did not find GMO as scary any longer. Other important items, for the opinions, which were brought up in the interviews were the time perspective, the purpose of the application, the idea of what is ‘natural’, and some pupils’ sense of contradiction between ‘heart and brain’.

Conclusion and implications
Even if more pupils were more positive after teaching, most pupils held the same opinion and used the same arguments and it is not possible to claim that teaching in general affected their opinions or argumentation. It was rather difficult to come to a decision. According to their own judgement, the most important factors for decision-making were knowledge and risk assessment. Knowledge worked in two ways. Some pupils expressed that they had learnt about techniques which made them feel more secure. Other pupils said that they had learnt more about ecological risks and therefore felt more hesitant. There were also pupils who referred to knowledge about herbicides and spraying. This information was often misunderstood.

The pupils tried to get a picture together in an area, which they found rather difficult, and they often declared that they needed to know more. Most of the pupils reasoned a lot, trying to include doing good things without taking risks and using their knowledge to come to an opinion about genetically modified plants. They were prepared to change their opinion if they could be given guarantees for safety or if they would get information about risks.

In order to do this in a qualified way pupils do not only need basic conceptual knowledge in science but also specific knowledge about the actual cases. They also need to know more about the nature of science and scientific work. One conclusion is that most pupils need more tools to judge information and more knowledge of the nature of science to feel confident.

A suggestion is to let pupils choose different areas of gene technology and go into detail rather than learning something about a number of different areas. As Lewis and Leach (2006) show, pupils do not need huge amounts of knowledge, but the learning tasks have to be well designed and contextualised. Then it is up to the teacher to guide the pupils in critical thinking, analyzing arguments and motivating their own standpoints. Then the pupils might be both more critical and more secure. If they learn what questions to ask and how to interpret information, their opinions might be formed on more specific arguments rather than on general fear or trust.

References
The goal of scientific and technological literacy


Handling of natural growth in interdisciplinary science lessons - seeing global problems of environment relevance from the local perspective of students

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Background, aims and framework

In all developed countries student attitudes towards science teaching are generally negative. The absence of positive attitudes means that students may never use their knowledge in everyday life and only seldom choose a career which is somehow related to sciences.

TIMSS 2003 showed that the attitudes of students toward science and scientific knowledge are significantly more positive in other European countries and also in the United States than in Estonia (Martin, Mullis, Gonzales & Chrostowski, 2004). But knowledge and skills achieved in the science studies, achievement measured by TIMSS, were hardly different across these countries. The analysis of Estonian TIMSS 2003 also showed differences among three cognitive domains (Mere, Reiska & Smith, 2006). Other studies (Estonia, Germany 1996-1999) showed that Estonian students had very good declarative knowledge but German students were much more successful in applying knowledge in computer-simulated tasks (Dahncke, Behrendt & Reiska, 2001).

Many European curricula emphasize the importance of improving scientific knowledge, problem solving skills and conceptual thinking, as well as other universally recognized skills. The PISA 2006 scientific literacy framework consists of several interrelated aspects which are connected to students’ everyday lives:

- recognising life situations involving science and technology
- understanding the natural world, including technology
- demonstrating competencies
- responding with an interest in science, support for scientific inquiry, and motivation to act responsibly (OECD/PISA, 2006).

On the other hand many researchers have shown that students will learn science better if they are interested in it. Relevant science problems normally are not separated into school disciplines like biology, chemistry or physics, but into a complex form including lots of different aspects. One possible way of handling these problems is to work at least partly in an interdisciplinary manner.

The term ‘interdisciplinary’ is not used homogeneously in the scientific discourse. An interdisciplinary instruction model of Labudde, Heitzmann, Heiniger and Widmer (2005) is based on six dimensions. All dimensions and instructional categories are divided into subject level and curriculum level. The subject level is also divided into interdisciplinary, multidisciplinary and interdisciplinary in a strict sense. At the curriculum level, there are two forms of instruction: complementary and integrated.

Historical analysis of science studies reveals that during the last decades, greater emphasis has been put on integrated instruction in science in many countries (Berlin & Lee, 2005). There are several arguments and empirical findings, which support interdisciplinary education.

Our starting point is environmental education as a good example of an interdisciplinary approach in teaching. In this paper we focus on two central problems:

- How do students understand the relevance of environmental problems (a global versus local perspective)?
- What is needed to combine mathematics and environmental items? (concept of natural growth of environmental quantities/ e-function f(x)=e^x).

We started by a self-assessment of students based on TIMSS, had teaching activities on problems of natural growth, that normally follow the e-function f(x)=e^x, as well as in class, as in interviews.
In carrying out subject-based environmental education for secondary level I requires teaching the concept of natural growth by means of the e-function f(x)=e^x. This is understood to be a difficult problem.
That is precisely why the natural growth of important environmental quantities normally may only be touched on at secondary level I. The problem is just mentioned and some hints are added, that later teaching in mathematics and geography will provide more information.

The idea of our research project is how to steer clear of the demands that a mathematically correct teaching of \( e^x \) and \( \ln x \) respectively would cause secondary I students problems. This is shown to be possible, because only one property of these functions is necessary: The percentage \( p \) of growth per time-unit and the time \( t(2) \) needed for doubling of quantity are very simply connected: \( t(2)=\frac{70}{p} \) (because of \( \ln 2\approx 0.7 \)).

**Methods and samples**

The empirical part of the study was carried out in Estonia, Germany and in the United States. In Germany we also used the self-developed teaching unit of four lessons as a basis for the research program. The teaching was carried out in level 6 to 10 in middle school classes. The set has been up to 110 students.

The methods of data gathering used include classroom observation, paper/pencil tests, questionnaires and interviews. This methodology reflects a mixed qualitative and quantitative approach, used to find out not just the differences but also to assist in the explanation of differences.

We used classroom observation to record the activities of teachers and students. This was important for further explanation of the influence of school lessons on student knowledge but also gives some information about their attitudes.

In the paper/pencil tests the students had to solve some problems associated with natural growth.

To check student attitudes toward science and their information sources about different science domains we used questionnaires.

In addition we interviewed students in Germany. We wanted to observe their reasoning while solving special growth problems and while rating one global problem more important than others.

In the longer term we will complement the outcomes from this by data taken from concept maps from different subject areas, the centre of which is the concept of energy.

**Results**

There is a rather simple way to teach exponential growth without the difficult mathematics of \( f(x)=e^x \) and \( \ln x \). We did so by simple calculation of percentages and “doubling-periods” carried out by pocket-calculators and/or spreadsheets. It shows too that student progress during lessons is neither related to school type nor to grade.

The self-assessment shows the general attitude of students to science and science teaching. Roughly speaking they rate it positively. Despite their generally good attitude to them they don’t head for more science lessons in school nor do students in Estonia and Germany see any help from science for future life, neither as university nor as job applicants. This is noticeably different from students in the United States. They rate science as well as school science lessons as being a help for getting into the university of their choice and as support for daily life.

Dealing with three growth problems changes the students’ view on six typical problems of environment. They also change lists of priority of environmental problems as the reasons given for that.

The common result in all three populations is that there is a local rather than a global point of view. But the consequences for different items are not the same.

This is especially evident with regard to virus diseases (e.g. HIV, AIDS) and the exponential growth of the global population. Following the principle “What touches me has to be the most important environmental problem” brings about the same rating of virus diseases in Estonia, Germany and the United States but different ratings of the global population increase. In the United States the latter is rated as a severe problem because of the local experience of increase, in Estonia and Germany it is underestimated due to the opposite local experience of a decrease in national population, and is therefore rated as subordinate. This is evident before as well as after dealing with three problems of exponential growth.

**Conclusions and implications**

In all countries, even those students who showed a good knowledge in science (teacher rating), didn’t sufficiently refrain from a very personal point of view and kept to a local rather than to a global perspective.
The goal of scientific and technological literacy

It came as a surprise that the students have got more information about global problems from media and friends than from school. When giving reasons they refer to their knowledge from public discussion and never to knowledge from school teaching.

We are going to pursue our project line specifically by adding data from concept maps to study how students can link concepts between different subject areas. The findings so far encourage us to enlarge our research program.

References


Development of a multi-concept instrument to study the impact of socio-scientific issues on student interest in science
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Britt Lindahl britt.lindahl@hkr.se

Background
According to Ramsden (1998) an interest in questions of attitudes towards science has decreased since each study gives the same results and nobody knows what to do to change the students' attitudes. The current importance of this question needs to be emphasized even more strongly as young people's interest in scientific career is declining.

One way to increase student interest in science could be to bring in a humanistic perspective (Aikenhead, 2006). The relative absence of right answers and the high degree of autonomy and 'real world' connection that characterize socio-scientific issues (SSI) (Ratcliffe & Grace, 2003) are factors that may influence the quality of student experiences when learning science (Osborne, Simon & Collin, 2003). Thus, studying the impact of socio-scientific issues on student affective reactions during learning, and attitudes toward learning science, is highly relevant.

The relation between the characteristics of a learner, the learning situation and outcomes is complex and there is a need for research on how personal and situational factors interact in the forming of learning experiences and outcomes. To achieve that, we need to simultaneously take into account several different models and concepts. This paper concerns the development of instruments necessary to assess the multivariate characteristics of students, learning situations, and affective outcomes that are central in the understanding of how socio-scientific issues might contribute to high quality learning and positive attitudes to learning science.

Framework
Several surveys of studies on attitudes towards and interest in science have been completed and most of them, like Osborne et al. (2003), conclude that earlier research shows a complex picture, as the concept of an attitude is somewhat nebulous, often poorly articulated and not well understood. Kobala and Glynn (2007) claimed that we now have to take a multidimensional approach to understand student experiences during learning. It has been suggested that much of the ambiguity in education research is due to a failure to account for the complexity of factors that influence learning. Examples of such factors are; student emotions (Pekrun, Elliot & Maier, 2006), the instructional design, student attitudes toward learning science (Osborne, Simon & Collin, 2003), epistemological beliefs (Hofer, 2001), and interest, self-efficacy beliefs, and sense of autonomy (Ryan & Deci, 2000).

Windisch and Andre (1998) found that student epistemological beliefs functioned as predictors of learning outcomes only if the degree of autonomy in the learning situation was considered simultaneously, arguing that the match between the characteristics of the situation and student epistemological beliefs elicited affective reactions that regulated student behaviour during learning and, eventually, learning outcomes. Another example comes from research on cognitive load and mental effort (Paas, Tuovinen, van Merrienboer & Darabi, 2005). While cognitive load is the proportion of an
individual’s working memory processing capacity that is required to solve a task, mental effort also takes into account the learner’s motivation to do so, i.e. a measure of the cognitive capacity that is actually invested in the task. Hence, mental effort results from an individual’s interaction with a learning situation and reflects the learner’s knowledge in the domain, his/her motivation to engage in the task (influenced by task value and complexity, self-efficacy and sense of autonomy) and, at least in the case of more ill-defined tasks, how the task is interpreted (involving the learner’s epistemological beliefs). If the complexity of the task is too high in relation to the learner’s prior knowledge, effective processing of the information is hampered, ultimately affecting the learner’s ability to solve the task - and the affective experiences during learning.

**Aims**

The aim is to develop an instrument that simultaneously considers the characteristics of the student, the situation, and the outcomes. We want to investigate this instrument’s ability to indicate which personal and/or situational characteristics are the most important in describing variation in student behaviour during learning as well as affective and perceived cognitive outcomes.

**Method/Results**

**Construction and categorization of items**

A large number of items were collected from extant questionnaires and, when necessary, adapted to Swedish conditions. Additional items were constructed, based on theory within the relevant fields of research. Items were categorized through Principal Component Analysis (PCA) of 1276 responses to the questionnaire, paralleled by discussions between researchers. The final categories, and the descriptive ($R^2$) and predictive ($Q^2$) ability of the PCA models describing the categories, are found in Table 1.

**Table 1** The categories, the contextual aspects they relate to (Personal, Situational, and Outcome), and number of components and statistical performance of the corresponding PCA model.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Items</th>
<th>Comp</th>
<th>$R^2$ (%)</th>
<th>$Q^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Attitudes and goals (P)</td>
<td>43</td>
<td>3</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>2 Beliefs about learning (P)</td>
<td>20</td>
<td>1</td>
<td>23</td>
<td>14</td>
</tr>
<tr>
<td>3 Self-efficacy / locus of control (P)</td>
<td>16</td>
<td>2</td>
<td>55</td>
<td>39</td>
</tr>
<tr>
<td>4 Ordinary work forms (P)</td>
<td>7</td>
<td>2</td>
<td>45</td>
<td>-6</td>
</tr>
<tr>
<td>5 Work forms during SSI-work (S)</td>
<td>17</td>
<td>3</td>
<td>40</td>
<td>44</td>
</tr>
<tr>
<td>6 Affective outcomes (O)</td>
<td>19</td>
<td>1</td>
<td>38</td>
<td>31</td>
</tr>
<tr>
<td>7 Cognitive outcomes (O)</td>
<td>11</td>
<td>1</td>
<td>33</td>
<td>20</td>
</tr>
</tbody>
</table>

All models showed intelligible distribution of items on the different components (describing the underlying “features” that connect items to each other) and correlation patterns. The descriptive and predictive ability ranged from moderate to good, with the exception of the “work form”- models that had poor predictive ability – possibly indicating the lack of an underlying construct that link the different work forms.

**Prediction model**

The large number of variables, although improving reliability of the instrument, makes interpretation of the relations between them difficult. Therefore, hierarchical PLS analysis was applied to items in categories 1-5 respectively to investigate their relation to outcomes and to “condense” items (i.e. personal and situational characteristics) into latent components. Then the latent components from all categories were pooled and their relations to affective and cognitive outcomes were examined in a “top model”. Table 2 shows number of components and performance of the PLS models on separate categories and the top model.

The single categories “Attitudes and goals” and “Work forms during SSI work” seem useful for predicting outcomes. However, the top model that includes components from all categories is better at describing and predicting variation in outcomes than any single-category model, which supports the idea that we need to consider several variables simultaneously. Response permutation testing, and external dataset validation of the top model supports its validity (data not shown). Details on the validation process and the specific original variables that were most influential in the prediction of affective and perceived cognitive outcomes are available.
Table 2  Number of condensed variables in each category, percentage of described variation in the independent variables ($R^2_X$) and outcomes ($R^2_Y$), and predictive ability ($Q^2$) of models

<table>
<thead>
<tr>
<th>Category</th>
<th>Comp.</th>
<th>$R^2_X$</th>
<th>$R^2_Y$</th>
<th>$Q^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Attitudes and goals</td>
<td>2</td>
<td>28</td>
<td>43</td>
<td>37</td>
</tr>
<tr>
<td>2 Beliefs about learning and knowledge</td>
<td>1</td>
<td>22</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>3 Self-efficacy/locus of control</td>
<td>2</td>
<td>50</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>4 Ordinary work forms in science class</td>
<td>1</td>
<td>29</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>5 Work forms during SSI-work</td>
<td>2</td>
<td>36</td>
<td>44</td>
<td>38</td>
</tr>
<tr>
<td>Top model:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Components from category 1-5 vs. outcomes</td>
<td>2</td>
<td>47</td>
<td>56</td>
<td>56</td>
</tr>
</tbody>
</table>

Conclusions and implications

Initial PCA models (Table 1) support the categorisation of items. The top model was able to indicate the relative impact of the categories on cognitive and affective outcomes (figure not shown). Most categories contributed, although in varying degree, to the predictive ability of the top model, supporting the validity of the multivariate approach. Although there is a need for a more in-depth investigation of patterns of causality (scheduled within the project during 2008), the potential implications of a deeper understanding of these relations are obvious to anyone interested in instructional design.

References


Elevers motivation afhænger af andet end undervisningens faglige indhold

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Baggrund

En række undersøgelser (Simon, 2000) har vist, at elevers interesse for naturfagsundervisningen falder med alderen, især i teenageårene. Dette fald i interesse kan både være betinget af undervisningens faglige indhold og/eller undervisningens organisering. Indenfor de seneste år har der været gennemført en række undersøgelser af unges interesse for naturfag, og hvilke fagområder der har deres interesse fx ROSE undersøgelsen. Den danske del af ROSE undersøgelsen har bl.a. vist, at der er stor forskel på piger og drenges interesse indenfor naturfag; drengene er interesserede i våben og eksplosioner, mens pigerne er mere interesserede i krøppen og relaterede spørgsmål (Sjøberg & Busch, 2005). ROSE og lignende undersøgelser giver et indblik i de unges umiddelbare interesser, og det kan som underviser være en fordel at have en sådan indsigts, men det er mindst lige så vigtigt at have kendskab til, hvordan elevernes motivation og interesse kan stimuleres gennem undervisningen.

I den foreliggende undersøgelse er det både blevet undersøgt, i hvilket omfang elevernes motivation for naturfagsundervisningen er betinget af deres spontane interesse for undervisningens faglige indhold og i hvilket omfang den stimuleres af undervisningens organisering og aktiviteter.

Undersøgelsen og undersøgelsesmetoder
Elevernes motivation og interesse er blevet undersøgt i forbindelse med et etårigt forløb, hvor kemi- og biologiundervisningen har været organiseret som tværfaglige temaer og projekter. Undersøgelsen er blevet gennemført på tre danske tekniske gymnasier (højere teknisk eksamen, htx), hvor 250 elever fra 10.1.års klasser har deltaget i undervisningsforsøget. Eleverne er blevet i løbet af året arbejdet med forløb omkring “Brød og bagning”, ”Jord og planter”, ”Krop og kemi” og ”Nærings- og nydelsesmidler”, og der er løbende sket en progression i elevernes valgfrihed og selvstyring.

Udviklingen i elevernes interesse og motivation er fulgt gennem interviews, observationer og spørgeskemaundersøgelser. Først og sidst i forløbet er elevernes interesse for forskellige kemiske og biologiske emner blevet vurderet som en del af en større spørgeskemaundersøgelse. Spørgeskemaet indeholdt 35 spørgsmål, hvor eleverne skulle tage stilling til ”Hvor stor er din interesse for at få mere at vide om...” (5-punkts Likertskala). Derudover blev elevernes motivation vurderet efter hvert af de tværfaglige forløb både med spørgeskemaer og elevinterviews. Alle elever har i løbet af året udfyldt 5 spørgeskemaer, og 26 elever har deltaget i et eller flere interviews. De interviewede elever er blevet udvalgt, så de repræsenterer et bredt udsnit af eleverne på teknisk gymnasium.

Resultater
De fleste htx-elever har en positiv holdning til teknik og naturvidenskab, og undersøgelsen viser da også vist, at mange af eleverne kom med en interesse for kemi og biologi - især kemi. I gennemsnit var eleverne mest interesserede i at lære om våben og sprængstoffer, hvilket hænger sammen med, at mange af eleverne var drenge (ca. 80%). Htx-pigerne var – som andre piger – mere interesserede i emner med relation til kroppen. Både drenge og piger adskilte sig fra andre unge ved at have en relativ stor interesse for rene kemiskemmer fx var ”Kemiske stoffer og deres egenskaber” nummer 8 på hitlisten over interessante emner (35).

Eleverne var indledningsvist knap så interesserede i biologi, og de havde ringe interesse for et emne som ”Planters vækst og formering” (nummer 34 på hitlisten). På det grundlag kunne det forventes, at det ville være svært at motiverere eleverne for et tema som ”Jord og planter”, men undersøgelse viste, at 53% af eleverne havde oplevet temaet som spændende og interessant. Flere elever gav i interviewene udtryk for, at det havde været spændende at få kendskab til jordens betydning for planters vækst, en elev sagde således:

Jeg havde det også sådan lidt med jord… Førhen så var det sådan, at ”jord det var bare jord”… men der er jo et hav af opbygning: mosejord, muldjord, lerjord… der er jo al mulig jord.

Også hvad det gjorde ved planter, hvad der levede lige der. De planter de kan kun leve lige nøjagtig der med den pH værdi. Det synes jeg, det er helt vildt spændende.

Flere af eleverne gav også udtryk for, at det havde været overraskende interessant at grave huller, undersøge jordprofiler og analysere jordprøver. Eleverne kom med flere udtalelser, der viste, at deres vurdering af forløbet afhænger af emnet. Ovenstående citater er også et eksempel på, at elevers interesse kan stimuleres ved det, at de får ny indsigt og viden. De interviewede elever er blevet udvalgt, så de repræsenterer et bredt udsnit af eleverne på teknisk gymnasium.

Jaa... nej... Jeg ville hellere have haft om kartofler, men når de er to [andre i gruppen]... og jeg synes jo også, at det er lige meget, hvad man kommer i gang med, der er jo altid noget spændende noget... Det er godt nok.
I løbet af året er der sket en generel stigning i elevernes interesse for kemi og biologi, eleverne har således fået større interesse for 22 af 35 emner i spørgeskemaet. Stigningen har især været markant for de emner, der har indgået i undervisningen. Eleverne har bl.a. fået større interesse for fødevarer, krop, sundhed og planters vækst, hvilket sandsynligvis udspringer af de gennemførte temaer og projekter, se nedenstående tabel. Planters vækst har dog ikke udviklet sig til et yndlingsemne, men det har bevæget sig væk fra bunden af hitlisten.

**Tabel 1** ◊ øget interesse; ◊ ◊ kraftig øget interesse

<table>
<thead>
<tr>
<th>Øget interesse for at få viden om:</th>
<th>Måske inspireret af forløbet om:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produktion og kvalitet af fødevarer ◊◊</td>
<td>Brød og bagning</td>
</tr>
<tr>
<td>Planters vækst og formering ◊◊</td>
<td>Jord og planter</td>
</tr>
<tr>
<td>Kroppens opbygning og funktion ◊◊</td>
<td>Krop og kemi</td>
</tr>
<tr>
<td>Medicin og dens virkning i kroppen ◊</td>
<td></td>
</tr>
<tr>
<td>Kost og sundhed ◊</td>
<td>Nærings- og nydelsesmidler</td>
</tr>
</tbody>
</table>

Den øgede interesse er sandsynligvis stimuleret af undervisningens organisering, hvilket understøttes af ndersøgelser der viser, at de fleste elever er positive overfor en undervisning baseret på temaer og projekter, kun 15% af eleverne foretrækker traditionel undervisning.

**Diskussion og konklusion**

I løbet af året med tværfaglige forløb er der sket en stigning i elevernes interesse for en række kemiske og biologiske emner. Der er især sket en stigning i deres interesse for biologirelaterede emner, hvilket understøttes af elevernes øgede engagement i biologi som undervisningsfag. Det kan dog ikke afgøres, om den øgede interesse skyldes de tværfaglige forløb eller andre forhold på teknisk gymnasium. Det er usandsynligt, at overgangen alene kan foranledige den øgede interessen, idet andre undersøgelser har vist, at interessen for naturfag ofte falder i forbindelse med overgange i uddannelsessystemet.


**References**


**Analyzing cases in technology and design education: enhancing understanding of natural science principles**

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Knowledge Promotion (Utdanningsdirektoratet, 2006a) is the most recent curriculum for the Norwegian 10-year compulsory school. *Technology and Design (T&D, Utdanningsdirektoratet, 2006b, p. 3)* is a new main subject area in natural science. T&D is to be integrated into the teaching of natural science, arts and crafts, and mathematics. The main goal is that pupils should be able to plan, develop and make useful products: “The interaction between natural science and technology is a key part of this main subject area. Natural science principles constitute the basis for understanding technological activities.” (p. 3).
The goal of scientific and technological literacy

This analysis of T&D education is based on case studies in three schools. The research question is:

- How can designing and making technological products be a vehicle for enhancing understanding of natural science principles?

The main outcome is that the actual T&D project seems successful in developing pupil skills in designing and making products, and T&D has a great potential to be a vehicle for enhancing understanding of natural science principles.

**Background, aims and framework**

The *Knowledge Promotion* (KP06) was implemented in 2006. T&D has competence aims to be reached after year 2, 4, 7 and 10 (Utdanningsdirektoratet, 2006b). The present study considers one typical T&D-project, designed to meet two competence aims after year 10:

The pupil shall be able to

- develop products based on specifications that use electronics, evaluate the design process and assess product functionality and user friendliness
- test and describe characteristics of materials used in a production process (p. 9)

A co-national/Oslo project *Lead, Prioritize and Organize. School development through focus on results and teaching practice in natural science and mathematics* (LPO) (Utdanningsetaten, 2006) supports the implementation of KP06. Some participating schools focus on T&D. The author is a science advisor to teachers and school project groups in science, collaborating with advisors in design. In the actual T&D-project the specification was:

You shall design and make an electronic badge with three diodes, one oscillating. The badge should be made in plastazote from a template made of cardboard and paper. Maximum size is 12 cm by 12 cm.

The diodes are soldered in series on a cardboard using a soldering iron with a clips-in 9V battery. Plastazote is a cross-linked closed cell polyethylene nitrogen expanded thermo plastic foam. A 3 mm black or white plastazote was used as a relative stiff background of the badge, and 2 mm plastazote in different colours to make the details. The parts were 'baked' at 200 °C for 2 minutes and then pressed together for 20 seconds. The diodes appear in three holes in the plastazote badge.

KP06 (Utdanningsdirektoratet, 2006b) does not discuss what is meant by ‘natural science principles’. Given that the curriculum states “the interaction between natural science and technology is a key part of T&D” (p. 3), ‘natural science principles’ are interpreted as understanding science principles in the context of a T&D project (Table 1).

**Table 1** Natural science principles and concepts which could be taught during the badge project

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electricity, electronics</td>
<td>Series and parallel circuits, components, current [A], voltage [V], resistance [Ω], power [W]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less obvious: Generating and storing electrical energy, use of electrical energy in the society, environmental aspects of electrical energy use</td>
</tr>
<tr>
<td>2</td>
<td>Basic chemistry</td>
<td>The periodic table, in particular explanation of conductors, semiconductors and isolators, and melting points of metals (soldering)</td>
</tr>
<tr>
<td>3</td>
<td>Plastic chemistry</td>
<td>Thermoplastics and thermostetting plastics, types of plastics, formation of fossil oil and gas, process from oil to plastics, environmental aspects of the use of plastics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less obvious: Energy laws, chains, quality</td>
</tr>
<tr>
<td>4</td>
<td>Energy, heat, warm</td>
<td>Energy sources, types, less obvious: Energy laws, chains, quality</td>
</tr>
</tbody>
</table>

In spite of LPO’s general focus on science and mathematics, two schools (A, B) focused mostly on design and production. Their projects lasted 7-8 hours. The third school (C) followed my advice and put the project in what I call a learning chain with science and mathematics (Hansen, 2007) (Figure 1) without diminishing design and production aspects. All classes in the third school started with 10-12 hours traditional hands-on teaching to meet one competence aim in KP06:

The pupil shall be able to explain results from experiments with electrical circuits using terms such as current, voltage, resistance, output and induction (p. 9)

This ‘theoretical’ start might have a positive influence on designing and making (6 hours). The learning chain was completed with 1-2 hours of solving mathematical problems in the electronic badge context. There was no time for analyzing everyday plastic-electronic products (Figure 1).
Another area of natural science principles (Table 1) is chemistry, but was not included in the learning chain although parts of two competence aims seem to fit:

- carry out experiments with and describe hydrocarbons
- explain how crude oil and natural gas are used (p. 9)

**Figure 1** A possible learning chain in an electronic badge project.

**Methods and samples**

Analyzing T&D education is a new international research area as is development of adequate methodology. T&D in Norway is new and different from that in other countries (which also differ much, as can be seen in deVries & Mottier, 2007).

The methodology used in this study has elements from two other research projects. One starts with a broad description of eight different cases (de Vries, Custer, Dakers & Martin, 2007). These cross-case studies encompass ten aspects of technology education: technological literacy, ethics, culture, design, stakeholders, attitudes, motivation, teaching, social aspects and differentiation. The second, the only Norwegian thesis on T&D-teaching, used analytical generalisations to identify as many aspects of T&D-teaching as possible (Bungum, 2003).

The present analysis includes three aspects: technological literacy (limited to understanding of natural science principles in the badge project), stakeholders (pupils, teachers, project groups, directorate for education i.e. KP06) and teaching. Several instruments were the same as those used by Bungum (2003): observations (often participant, conversation), interviews (semi-structured, open-ended questions) and pupil design-portfolios. Photographs were used, but no tape recordings. Like Bungum I used “quasi-quantitative measures such as ‘all,’ ‘many’ and ‘few’” (p. 83).

The population is about 350 pupils in 14 grade 9 classes, at three LPO-schools. A sample of four classes was selected for observations. Notes were taken, and rewritten afterwards. When finishing two classes at two schools (A, B), I extended data collection with interviews at school C to reflect my observational impressions. The pre-defined opening questions were:

- Explain how your electronic circuit functions.
- Why did your plastazote soften when heated and stiffen when cooling again?

Seventeen pupils from two classes were interviewed, and the answers were noted in an interview guide constructed from Table 1. Pupil design portfolios in all fourteen classes were inspected. Some photos were taken to support notes from observations. During the observations I also conversed with the teachers. Planning and evaluation meetings in the project groups gave valuable insight into teacher interpretation of the actual competence aims, the implementation of the project, and teacher impressions of pupils attained skills and knowledge.

**Results**

The designing and building of badges is not deeply analyzed, but all pupils made successful soldering and most badges were skilfully made in good, often funny designs. Schools A and B have both, according to the teachers and project groups, emphasised the design process at the cost of including science. Conversation with the pupils during the design and making process revealed that most of them demonstrated only rudimentary knowledge in electricity recalled from earlier instructions, and did not have the same ‘fluency’ in using the right concepts as most pupils in school C. In spite of emphasising design at A and B, the pupils in these two schools demonstrated no knowledge of chemical characteristics of the materials (neither did pupils in school C). The impressions from conversations are consistent with the impressions from examining the design-portfolios and conversation with their science teachers and the project groups’ evaluation of the badge project.
Many pupils in school C were able to use basic concepts in a theoretically correct way when discussing solutions of making the electronic circuit for their badges. The interviews confirmed the impressions. More than half the pupils demonstrated good to excellent understanding of electrical circuits and the function of the components. Most of them knew the difference between current and voltage. Less than half were at the same low level as most pupils in A and B had demonstrated in conversations. Very few had no knowledge. No pupils showed good to excellent knowledge on the chemistry question. Common answers were like: ‘The plastazote is nearly melting when heated and then cooling back to shape again’. They could hardly say anything about what happens inside plastics when ‘melting’. Words like ‘atom’ and ‘molecule’ were not used. Very few knew what plastics are made from.

Conclusions and implications
The badge project demonstrates areas of technology where the interaction between natural science and technology is obvious. The project fits well into a learning chain (Figure 1). The natural science principles in electricity, electronics, plastic chemistry and energy use could be developed and easily used in this practical context, with potential to give positive feedback and further knowledge development. The different level of knowledge about electronic circuits between pupils in schools A and B and the pupils in school C could be due to the design of the badge project where in school C the project was put into a learning chain, while at schools A and B the focus was on design. The plastics-chemistry knowledge was not included in the chain, and the results in C did not differ from A and B. The continuation of the badge project learning chain could be to analyse some everyday products made of plastics covering electronic and electrical systems. This could also lead to some environmental and consumer political discussions in the classroom.

A small population and samples, limited examinations and experience from only one T&D-project, limits the possibility to generalize. But, it seems like designing and making useful technological products could be a vehicle for enhancing understanding of natural science principles if the pupils get the opportunity to develop and use science in a technological context. This is in accordance with Dakers’ (2006) general conclusion from analyzing eight very different cases: “Procedural knowledge [designing and making] and conceptual knowledge were all seen to synthesise, thus forming a learning space where technological literacy could be developed” (p. 136). Technological literacy includes understanding of natural science principles as a basis for technological activities. The learning-chain principle is one possible ‘learning space’ for a good T&D-project.

References


Några uppgifter som belyser elevers uppfattningar om vad som är teknik

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Bakgrund, utgångspunkter och syfte

Mål och inriktning varierar också mellan länder, Teknikens roll i samhället och behovet av att fatta kloka beslut om dess användning betonas exempelvis starkt i Saskatchewan, men är relativt perifert i England, där designprocessen dominerar.
Den svenska kursplanen understryker både att kunna göra tekniska konstruktioner och resonera om tekniken i samhället.

En bidragande orsak till den nu antydda variationen i olika länder teknikundervisning torde vara att teknik är ett mycket stort kunskapsområde, vilket ger många valmöjligheter. Nationalencyklopedin (1995) ger följande definition:

**teknik**, sammanfattande benämning på alla människans metoder att tillfredsställa sina önskningar genom att använda fysiska föremål. Föreställningen att all teknik är tillämpad naturvetenskap är missvisande. Naturvetenskaplig kunskap har ofta uppstått ur tillämpad teknik (sidan 141).


Tio år tidigare administrerades i USA ett test kallat ”Pupils’ Attitudes Toward Technology” till omkring 10 000 elever i åldrar motsvarande grundskolans senare del och gymnasiet. Testet utgörs av 100 påståenden som man skall instämma i eller ej enligt en femgradig skala. Det var 54% som instämde i ”When I think of technology I mostly think of computers”. Ett annat påstående var ”In my opinion, technology is not very old.” Det var 35% som höll med om detta (Bame, Dugger, de Vries & McBee, 1993).

Mot bakgrund av ovanstående blev vi intresserade av att undersöka om svenska elever skiljer mellan naturen och tekniken samt vad de uppfattar som exempel på teknik.

**Metod och urval**


**Vad blir kvar av staden?**

Denna uppgift fick vi idén till då vi läste en skildring av vad som skulle bli kvar av en stad om allt som tekniken har tillfört försvann (National Research Council & National Academy of Engineering, 2002:48). Eleverna fick frågan:

> Vad blir kvar av en stad om man tar bort alla tekniska produkter och system?

Sedan följde en lista där eleverna för olika exempel fick kryssa i ett av alternativen ”blir kvar”, ”blir inte kvar” eller ”jag vet inte” (se Tabell 1 i resultatdelen).

**Vad tillhör teknikens värld?**

Nästa uppgift inleddes med frågan:

> Vad blir kvar av en stad om man tar bort alla tekniska produkter och system?

Sedan följde en lista där eleverna för olika exempel fick kryssa i ett av alternativen ”räknas som teknik”, ”räknas inte som teknik” eller ”jag vet inte” (se Tabell 2 i resultatdelen).

**Vad är teknik?**

Den tredje uppgiften började så här:

> I skolan får du lära dig vad teknik är. Här följer några påstående om tekniken i vår omvärld. Håller du med eller ej? Sätt kryss!

Sedan gavs åtta påståenden för eleverna att ta ställning till genom att välja ett av alternativen ”håller med”, ”håller inte med” och ”jag vet inte” (se Tabell 3 i resultatdelen).
Resultat

Vad blir kvar av staden?
Uppgiften besvarades av 190 elever. I redovisningen har vi slagit ihop årskurs 7 och 8 till en grupp. Det var enbart 21 elever i årskurs 7 som fick frågan. Resultatet framgår av tabell 1.

Tabell 1  Andel elever (%) som anger att olika saker blir kvar i en stad då man tar bort alla tekniska produkter och system.

<table>
<thead>
<tr>
<th></th>
<th>Åk 7 &amp; 8 n=115</th>
<th>Åk 9 n=75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flugor</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>Luft</td>
<td>91</td>
<td>93</td>
</tr>
<tr>
<td>Regnvatten</td>
<td>89</td>
<td>93</td>
</tr>
<tr>
<td>Ögräs</td>
<td>92</td>
<td>89</td>
</tr>
<tr>
<td>Brod</td>
<td>80</td>
<td>55</td>
</tr>
<tr>
<td>Statyer</td>
<td>57</td>
<td>49</td>
</tr>
<tr>
<td>Kläder</td>
<td>48</td>
<td>39</td>
</tr>
<tr>
<td>Hus</td>
<td>42</td>
<td>36</td>
</tr>
<tr>
<td>Dricksvatten</td>
<td>34</td>
<td>33</td>
</tr>
<tr>
<td>Mediciner</td>
<td>21</td>
<td>19</td>
</tr>
<tr>
<td>Avloppsledn.</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Tidningar</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Bilir</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Datorer</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Av tabellen framgår en förbättring av resultatet med stigande ålder.

Vad tillhör teknikens värld?
Uppgiften besvarades av 154 elever. Resultatet visas i tabell 2.

Tabell 2  Andel elever (%) som anger att olika saker räknas som teknik.

<table>
<thead>
<tr>
<th></th>
<th>Åk 8 n=80</th>
<th>Åk 9 n=74</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dator</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td>Bro</td>
<td>81</td>
<td>91</td>
</tr>
<tr>
<td>Kärnkraftverk</td>
<td>81</td>
<td>90</td>
</tr>
<tr>
<td>Kulpruta</td>
<td>77</td>
<td>81</td>
</tr>
<tr>
<td>Västol</td>
<td>66</td>
<td>72</td>
</tr>
<tr>
<td>Roddbåt</td>
<td>56</td>
<td>65</td>
</tr>
<tr>
<td>Aspirin</td>
<td>36</td>
<td>47</td>
</tr>
<tr>
<td>Stenyxa</td>
<td>51</td>
<td>42</td>
</tr>
<tr>
<td>Tvål</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>Stickad luva</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>Målad tavla</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Rödvin</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Spagetti</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Regnvatten</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Gran</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Maskros</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Det finns också på denna uppgift en tendens till förbättrat resultat med stigande ålder.

Vad är teknik?
Uppgiften besvarades av 203 elever. Resultatet framgår av tabell 3.

Tabell 3  Andel elever (%) som instämmer i olika påståenden om teknik.

<table>
<thead>
<tr>
<th></th>
<th>Åk 8 n=68</th>
<th>Åk 9 n=135</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tekniken har en stor påverkan på oss människor.</td>
<td>93</td>
<td>96</td>
</tr>
<tr>
<td>Datorer, elektronik och robotar hör till det tekniska området.</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>Jag använder olika tekniska produkter dygnet runt.</td>
<td>79</td>
<td>87</td>
</tr>
<tr>
<td>Teknik har funnits så länge som det funnits människor.</td>
<td>46</td>
<td>66</td>
</tr>
<tr>
<td>Att sy med sytråd och vava tyger är en del av teknikens värld.</td>
<td>41</td>
<td>58</td>
</tr>
<tr>
<td>Tandborstar, plåster och toapapper räknas till området teknik.</td>
<td>41</td>
<td>43</td>
</tr>
<tr>
<td>Teknik är något ganska nytt som bara funnits några hundra år.</td>
<td>31</td>
<td>14</td>
</tr>
<tr>
<td>I mitt dagliga liv använder jag inte särskilt många tekniska produkter.</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

En ganska stor andel (14 %) väljer alternativet “vet ej” när det gäller påståendet om att teknik funnits så länge som det funnits människor.

Slutsatser och implikationer
Av resultatet framgår att eleverna uppfattar de system vilka är hämtade från naturen som åtskilda från teknikens värld. Detta kan inte tolkas som att de har en generell uppfattning om var gränsen mellan artefakter och natur går, men väl som ett tecken på att två betydelsefulla ontologiska kategorier hålls isär i det aktuella sammanhanget.
Det framgår vidare att elevernas uppfattning om vad som är teknik är begränsad. Liksom i andra studier är det datorn som toppar listan, men det är bara cirka en tredjedel som menar att vardagsbetonade tekniska produkter som tvål och stickad luva är exempel på teknik.

Eftersom alla tillfrågade elever har mött ämnet teknik drar vi för svensk del den preliminära slutsatsen att undervisningen inte leder till en generell kunskap om vad som hör till området teknik. Detta kan få olika konsekvenser, exempelvis när det gäller framtida yrkesval.

En intressant fråga är om lusten hos lärare för yngre elever att undervisa om teknik påverkas av deras uppfattning om vad som hör till området. Om läraren, som i de flesta fall är en kvinna, ser datorer, elektronik och arbete med skiftnyckel, skruvmejsel och andra verktyg framför sig kan området te sig både oöverstigligt och svårt. En bred teknikuppfattning öppnar däremot för stora möjligheter att välja teknikområden efter lärarens intresse och kunnande.

References


Planning science instruction: From insight to learning to pedagogical practices

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

Synopses: Understanding scientific concepts

December 2008
Understanding scientific concepts

2008 Science Education Research Group
School of Education
University of Iceland

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**Understanding scientific concepts**

Student understanding about water transport in the human body and why water is healthy
*Pernilla Granlint Enochson, Gustav Helldén and Britt Lindahl*

How students from age 7 to 16 use their experiences when developing their ideas about transformations of matter
*Lena Löfgren and Gustav Helldén*

Student reasoning about redox reactions in three different situations
*Liselotte Österlund and Margareta Ekborg*

Samband mellan gymnasieelevers studiemönster och kunnande i evolutionsteori ett år efter undervisning
*Anita Wallin*

Student teacher content knowledge of life in an aquatic ecosystem and their experience in a teaching situation – a case study
*Hans-Olof Höglund, Gustav Helldén, Maria Thomasson and Sara Wahlberg*

Student teacher use of communicative support to make meaning of abstract phenomena in the content area of energy
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Student teacher conceptions of matter and substances – some results from 31 interviews
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Mångtydigheten hos begreppet temperatur
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Referent change, a neglected aspect in traditional conceptual change approaches to science learning and teaching
*Helge Strömdahl*
Student understanding about water transport in the human body and why water is healthy

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Background, aims and framework
Knowledge about the human body is an important part of the school curriculum and there are several studies of student ideas about the function of the body. According to the Swedish curricula students should at the end of the ninth grade (aged 15/16) should be familiar with the organs of their own bodies and how their systems function together, the effects of addictive substances on health, and should have an ability to take part in discussions on the importance of regular exercise and good health habits (Skolverket, 2007).

Results from an international study (Reiss et al., 2002) about student understanding of different organ systems show that generally the best known organs belong to the digestive system, the gaseous exchange system and the skeletal system. Tunnicliffe (2004) found that 9-10 year old students had greater difficulties in understanding the excretory systems than the digestive system. A Swedish study has shown that students have many different opinions about what happens in the body when they drink a glass of water (Granlkint, Enochson, Helldén & Lindahl, 2007). In another study 10 year old English students explained what would happen to food when they eat (Rowlands, 2004). Seven of the twenty-five students had some understanding that there were two separate systems in the body, one for solid food and one for drinks. There were no indications that any child had any knowledge about the chemical change of the food. Many of the students thought that food could be separated by the body into two parts, healthy and unhealthy food. With some help from the teacher, the students understood that food is broken down into small pieces. Most students understood that the circulatory system was involved in the process (Rowlands, 2004).

In Sweden and England one study investigated student ideas about “good health”. Most of the students in both countries comprehended that diet and exercise were important for good health (Turner, Öberg & Unnerstad, 1999). It seems that students have difficulties in understanding the human body functions, but they commonly have knowledge about how to live a healthy life. The ideas about the body functions are constructed in many ways in student minds.

Student ideas about what happens in the body when drinking water are poorly investigated, so that is an interesting issue to study further.

Methods and samples
Templates of a human body were used to collect data for the first part of the study. Three papers with templates of the human body with different questions were given to 84 students in grade 9. In this study one of the drawings with the question “What happens in your body when you drink water?” has been analysed. This question was given to 55 students. To get more information from the students, the templates were followed by an open question concerning a health issue and by two multiple choice questions concerning physiology: in this case the main function of the kidney, and reason for sweating. Twenty students were interviewed in order to get a deeper knowledge of their argument. The students have been taught by their ordinary teachers and the lessons have included lectures and laboratory experiments. When the investigation took place the students had completed all the human physiology sections in the obligatory school curricula.

Results

Template
The drawings have been categorised into four categories. Every main category has been divided into subcategories. The four main categories are:

- Understanding not present (9 students) 16%
  - Not answering the question (3)
  - No answer (6)
- Alternative understanding (13 students) 24%
  - In mouth and out in the body (3)
  - Tube from mouth to the urinary bladder (3)
  - Tube from mouth to the kidney (7)
• Incomplete understanding (31 students) 56%
  - Mouth and stomach (19)
  - Mouth, stomach and intestine (12)
• Good understanding for 9th grade students (2 students) 4%
  - With throat, stomach, intestines, circulatory system, kidney and bladder

Multiple choice questions
The answers to the two multiple choice questions were categorised in relation to the four main template categories (Tables 1, 2).

Table 1  Question about the main function of the kidney.

<table>
<thead>
<tr>
<th>Multiple choice question alternatives</th>
<th>Main categories of understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not present</td>
</tr>
<tr>
<td>To produce antibody against illness</td>
<td>11% (1)</td>
</tr>
<tr>
<td>To decompose food</td>
<td>11% (1)</td>
</tr>
<tr>
<td>To circulate the blood</td>
<td></td>
</tr>
<tr>
<td>To produce red blood corpuscles</td>
<td>22% (2)</td>
</tr>
<tr>
<td>To clean the blood of waste products (expected answer)</td>
<td>56% (5)</td>
</tr>
<tr>
<td></td>
<td>100 % (9)</td>
</tr>
</tbody>
</table>

Table 2  Question about the main reason why humans sweat.

<table>
<thead>
<tr>
<th>Multiple choice question alternatives</th>
<th>Main categories of understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not present</td>
</tr>
<tr>
<td>To keep body temperature constant (expected answer)</td>
<td>60% (6)</td>
</tr>
<tr>
<td>To keep the skin humid</td>
<td></td>
</tr>
<tr>
<td>For protection from catching a cold</td>
<td></td>
</tr>
<tr>
<td>To get rid of surplus salt in the body</td>
<td>30% (3)</td>
</tr>
<tr>
<td>To get rid of surplus water in the body</td>
<td>10% (1)</td>
</tr>
<tr>
<td></td>
<td>100% (10)</td>
</tr>
</tbody>
</table>

The open question
The open question was formulated: Why is it important to drink water? In all the main categories focusing on the importance to drink water for the survival was mentioned (Table 3). All groups except for those with good understanding, wrote about different illnesses the water protects them from, such as a headache. In the alternative and incomplete understanding categories there were some students who wrote that the water was an important nutrient. Except for the not present category all the others contain some students who had understood that water have to do with regulation and all students in the good category mentioned regulation.

Table 3  The open question: Why is it important to drink water?

<table>
<thead>
<tr>
<th>Main categories of understanding</th>
<th>Not present</th>
<th>Alternative</th>
<th>Incomplete</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival (expected answer)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Regulation (expected answer)</td>
<td></td>
<td>x</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Illness</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Nutrient</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection (skin)</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Conclusions and implications
The study of Granklint Enochson et al. (2007) confirmed that some students have an alternative understanding of the morphology of water transportation in the body. Students with an incomplete understanding have more knowledge of the function of the kidneys than the students who have an alternative understanding. The interesting thing is that most of the students carrying the alternative understanding draw kidneys on their template, in contrast with the students with an incomplete understanding. It seems that there is a connection between knowledge of morphology and physiology.

When it comes to the health issues the students with alternative and the incomplete understanding are relatively similar to each other in their answers to the open question. Both of them write that we need water for our survival on the earth
and that water has something to do with regulation, as we expected. But in both of these categories there are some students who believe that water has a capacity to save the body from illness and that water contains nutrients.

The students who didn’t present any understanding about human morphology and physiology do not show any deeper health arguments.

References

How students from age 7 to 16 use their experiences when developing their ideas about transformations of matter
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Background, aims and framework
In this paper we want to present results from a ten year longitudinal study in which interviews and student reflections on earlier interviews have been used to learn more about how students develop their understanding of transformations of matter.

Student difficulties in understanding processes where matter seems to disappear, as in decomposition or burning, or appears out of nothing, as in condensation, have been well documented in the science education research literature (Andersson, 1990; Driver, Guense & Tiberghien, 1985; Krnel, Watson & Glazar, 1998). Student ideas about transformations of matter in decomposition are highly related to their limited conception of the gaseous state (Helldén, 1995) and also include phenomena such as burning, evaporation and condensation (Helldén, 1999). Therefore in this study we wanted to learn more about how students actually make meaning and come to understand transformations of matter in decomposition, burning, evaporation, and condensation.

The aim of the study is to investigate:
• how students use experiences when they develop and express their ideas about decomposition, burning, evaporation and condensation.

The theoretical framework of this study builds upon human constructivism formulated by Joseph Novak (1993). This perspective underlines the unique interplay that occurs between thinking, feeling, and acting in human learning and also stresses the important role of language in learning processes. This perspective is in accordance with science concept learning as formulated by Scott, Asoko and Leach (2007).

Methods and samples
In our study (1997-2006) we followed 23 students all born in 1990. In spring 1997, 1999 and 2001 we had teaching sessions. Inspired by Novak and Musonda (1991) we had already in 1997 introduced the idea of the particulate nature of matter by introducing a simple molecule concept to the students. From autumn 2003 the students had more conventional lessons in biology, chemistry and physics.

We conducted interviews at least once every year allowing the students to explain the transformation of matter in three situations. The students have been interviewed 14 times. More details about the teaching sessions, interviews and student sample can be found in Löfgren and Helldén (2007a). The three situations asked about in the interviews were:
• the fate of decaying leaves left lying on the ground,
• the disappearance of the wax of a burning candle, and
• the appearance of mist on a piece of glass placed over a jug of water.

Helldén (2003) has shown that students often can shed light on their own statements by being allowed to comment on them at a later time. We therefore, in the interviews in 1998, 2000, and 2002, let the students listen to the interview from the year before and they were then asked to comment on their earlier statements. In 2005 the students listened to and commented on an interview from 2001. In the later interviews the students were also asked if they knew what had changed their ideas about the phenomena.
Results
As this is a longitudinal study some results have been presented earlier. The different conceptions the students expressed before 2001, in the different situations, are presented in Holgersson and Löfgren (2004). When analysing the interviews of the individual students until 2003, with Ausubel's assimilation theory we could discern subordinate, superordinate and combinatorial learning. We also found a common pathway of how the students' ideas changed over the years in each situation (Löfgren & Helldén, 2008). Results from specifically analysing the use of the molecule concept have been presented in conferences (Löfgren & Helldén, 2006, 2007). During all these analyses we have observed that many students describe the situations with a strong personal pattern.

In this analysis we concentrate on these personal patterns and try to understand how the individual student uses her or his experiences and reflections. When interviewed about the three situations some students explicitly relate their ideas to episodes inside and outside school, to things they have heard, or to other experiences which they associate with the things in front of them. Listening to how they described the situation earlier seems to elicit memories and reflections they had when interviewed. These insights help us understand and deeper analyse the meaning of the student descriptions and explanations of the phenomena. In the still ongoing analysis we try to connect this deeper understanding of the personal patterns also to the evidence of teaching influence. We can, for instance, see from the interviews that all students at almost the same age learn that leaves lying on the ground are eaten by animals and then turn into soil, and they also learn at the same, but another, age that oxygen is needed for burning to take place. On the other hand there are other facts and processes that only a few students seem to find useful in understanding of phenomena. On the whole there is a vast spread in student capability to use their experiences and taught facts in productive ways to improve their understanding of transformations of matter.

Conclusions and implications
There is a great difference in individual student learning pathways. Some students explicitly use their experiences and reflections when developing their ideas about the different phenomena and some do not. Most students change their ideas and make progress in describing and explaining the situations in the first years of the study. Later on there are greater differences meaning some students connect science taught in school with their ideas about the situations in a productive way, while others do not seem to make such connections. Following these individual student learning pathways, and noticing the lack of impact of school teaching on the pathways, we would emphasize the importance of finding methods to spread and discuss the results from recent decades of science education research among school teachers, teacher students, and curriculum designers.

References
Student reasoning about redox reactions in three different situations
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Margareta Ekborg margareta.ekborg@educ.umu.se

Background, aims and framework
The chemistry curriculum for Swedish upper secondary school states that students should learn the concepts oxidation and reduction (redox) and be able to apply them in an industrial and everyday context (Skolverket, 2000). Redox is perceived as one of the most difficult topics, both to teach and learn. The reactions are not fully understood (de Jong & Treagust, 2002) and students have difficulties transferring their knowledge of redox between different chemistry topics and life phenomena (Schmidt & Volke, 2003; Soudani, Sivade, Cros & Médimagh, 2000).

Chemistry is often taught without connection to everyday life. There is little or no learning transfer of chemistry for life-long learning (Gilbert, 2006). For chemically similar tasks but a shift in context, transfer of knowledge often fails (Blanchette & Dunbar, 2002; Soudani et al., 2000).

The aim of this study was to investigate secondary school students’ explanations of spontaneous redox reactions in three different situations. The situations were: A laboratory example of corrosion where iron and iron in combination with copper were investigated, and a demonstration experiment with zinc and copper sulphate solution. These were classroom situations. One situation was outdoors, a copper statue on a corroded stand.

The following research questions were posed:
• How do students in upper secondary school reason about redox reactions in different situations?
• What redox models do they use?
• How do they explain the reactions with reactants and products?
• How do they use the activity series of metals?

Throughout history four models for use in explaining redox reactions have developed. They are all used in chemistry education today. Ringnes (1995) has described the models, summarized in Table 1.

<table>
<thead>
<tr>
<th>Model</th>
<th>Reduction</th>
<th>Oxidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Oxygen model</td>
<td>loss of O</td>
<td>gain of O</td>
</tr>
<tr>
<td>2. Hydrogen model</td>
<td>gain of H</td>
<td>loss of H</td>
</tr>
<tr>
<td>3. Electron model</td>
<td>gain of electrons</td>
<td>loss of electrons</td>
</tr>
<tr>
<td>4. Oxidation number model</td>
<td>decrease in oxidation number</td>
<td>increase in oxidation number</td>
</tr>
</tbody>
</table>

The activity series of metals (abbreviated hereafter as ASOM) is a series arranging metals according to their ability to act as a reducing agent. It includes hydrogen (H) which indicates the metal’s ability to generate hydrogen gas from different sources. Ignoble metals are on the left side of hydrogen while the noble ones are on the right (Silberberg, 1996).

A common oxidizing agent is oxygen. When iron corrodes, iron atoms lose electrons to dissolved oxygen. The oxygen molecules reduce, react further with water molecules and produce hydroxide ions. The ions combine and form iron hydroxide, rust. Copper oxide forms when the copper atoms oxidize and oxygen becomes reduced (Silberberg, 1996).

Methods and samples
Participants
This study was conducted in a medium sized upper secondary school in northern Sweden. The group was in their second year of the natural science programme with 21 students (17 years). The previous year they had worked with electrochemistry, ASOM and oxides of copper. No teaching had been carried out on the standard electrode potentials.

During the lesson the teacher did a revision of the redox reactions and gave a brief overview of corrosion of iron. The lesson lasted about 45 minutes and included a lecture, a demonstration of zinc in copper sulphate solution and a dialogue with the students. A work sheet with lab instructions was distributed to the students to prepare as homework.

Interviews
Ten students volunteered for the interviews, five females and five males. Their grades were above average. The interviews were conducted on two separate occasions. The first individual semi-structured interviews were performed in a small group room after the laboratory work and lasted for 30-40 minutes. The topic was the laboratory work of corrosion and the displacement reaction with zinc and copper sulphate solution. On the second occasion semi-structured interviews were conducted outdoors at the copper statue, lasting for 15 minutes, with two individuals and four pairs of students. All interviews were audio recorded and transcribed verbatim.
Data analysis
The data have been inductively analysed, partly following Hatch (2002). The research questions, the interview guide, concepts from prior research and the data framed the analysis as themes were identified.

Results

Redox model
All the students explained oxidation and reduction as an electron transfer. Some of the students mixed up the meaning of oxidation and reduction, but they all indicated the use of the electron model in their explanations in all three situations.

In the laboratory work on corrosion, four of the students of supplemented the electron model in stating that oxygen as a substance was always a part of a redox reaction. We have considered this as having used the oxygen model to some extent. On the other hand, in the displacement reaction with zinc and copper sulphate solution, none of the students identified oxygen as a potential electron acceptor.

The majority of the students explained oxidation and reduction as mutual reactions in all three situations.

Reducing agent
In all the situations, the students had no difficulties in identifying the reducing agent in the reactions. In the situations in which metals were in contact, they used ASOM and reasoned in terms of noble and ignoble metals when identifying a reducing agent. The students said that ignoble metal lost electrons in the reaction and became oxidized.

Regarding the statue, almost all the students were aware that copper itself could act as a reducing agent, being a part of other redox systems besides the contact area between copper and iron.

Oxidizing agent
In the laboratory work of corrosion the majority of the students identified water as the oxidizing agent. Only a few students described dissolved oxygen as the oxidizing agent, which is scientifically correct. In this situation ASOM seemed an incomplete tool for reasoning redox reactions.

In the single displacement reaction all students asserted copper or copper ions as the oxidizing agent. Even if there was a mix between macroscopic (observable) and sub-microscopic (ions) expressions our interpretation is that the students had an awareness of what substance acted as the electron acceptor. In this situation ASOM seemed an aid in reasoning about redox reactions. In the outdoor situation the students could choose freely to reason about redox reactions around copper or iron or both metals of the statue. The majority of the students asserted oxygen as the oxidizing agent, in contrast to the isomorphic task of the laboratory work of corrosion. Even here ASOM seemed an incomplete tool for reasoning about redox reactions.

Chemical product
In the laboratory work of corrosion the majority of the students identified some form of iron oxide – rust, as the product formed during the reaction. Half of the students also declared that an additional product, hydrogen or oxygen gas was formed.

Regarding the statue, all students suggested iron oxide or copper oxide as the product. Here just one student declared gas as an additional product.

In the single displacement reaction, the majority of the students identified copper as a precipitate on the zinc plate and zinc ions as products, according to the scientific model. Some had difficulties in determining the constitution of the precipitate. The overall chemical reasoning in this redox reaction seemed to be unproblematic.

Conclusions and implications
All students use the electron model in their reasoning of redox reactions in every situation. Some students use the oxygen model in addition to the electron model in some redox reactions, i.e. in rust formation. The majority of the students asserted redox reactions as mutual reactions.

None of them had problems with identification of the reducing agent in any of the situations. The main problem for these students was to identify the oxidizing agent in the laboratory experiment of corrosion. ASOM was no help here. In this situation more than half of them also identified gas formation as a product of the reaction, which we interpret as an attempt to explain the reaction with the aid of the series.

Regarding the statue, most students reasoned from the copper metal and made a scientifically correct explanation of the redox reaction. The oxidation of copper is similar to a single displacement reaction, in comparison to rust, which
is a complicated reaction. Student explanations about the single displacement reaction of zinc and copper sulphate solution seemed rather unproblematic and the use of ASOM seemed reinforced. As ASOM became a limited tool in the student explanations of the laboratory work of corrosion, it would be helpful for the students to develop the series with non-metallic elements. This could be an "in between" step if the teacher decided to work with the standard electrode potential. In other cases this step could clarify for the students that redox reactions occur in accordance with reactions explained from ASOM but with a non-metallic electron acceptor. It would be easier to hold on to the electron model even if oxygen is part of the reaction.

References

Samband mellan gymnasieelevers studiemönster och kunnande i evolutionsteori ett år efter undervisning
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Introduktion och studiens kontext
Focus i denna studie var att undersöka om det finns något samband mellan kunnande i evolutionsteori efter undervisning och vilket angreppssätt eleven hade i sina studier, här kallat studiemönster.


Djupa och ytliga studiemönster

Syfte och forskningsfråga
**Genomförande**

*Elever, lärare och skolor*


**Undervisning och lärande i biologisk evolution**

Innan undervisningen startade besvarade eleverna ett förtest med sju uppgifter och ett år efter undervisningen ett eftertest med åtta uppgifter (se Tabell 1).

**Tabell 1  De uppgifter som ingick i för- och eftertesten.**

<table>
<thead>
<tr>
<th>Tema för uppgiften</th>
<th>Uppgiftstyp</th>
<th>För</th>
<th>Efter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation</td>
<td>Flerval</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Flerval</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Likert med motivering</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Arv</td>
<td>Likert med motivering</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Naturligt urval</td>
<td>Flerval</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Likert med motivering</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Evolutionsteori</td>
<td>Öppen uppgift</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Flerval med motivering</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Elevernas för- och eftertest kategoriserades med avseende användandet av alternativa (A) och/eller vetenskapliga (V) resonemang.

- Kategori AA: alternativa idéer konsistent
- Kategori AV: i enstaka uppgifter vetenskapliga idéer
- Kategori VA: i åtminstone hälften av uppgifterna vetenskapliga idéer
- Kategori VV: vetenskapliga idéer konsistent, maximalt en flervalsuppgift med alternativa idéer.

**Studiemönster**


Det blev ett bortfall av 11 elever från första experimentomgången p.g.a. att denna studie inleddes först under de senare undervisningssexperimenten. Det är dock ingen signifikant skillnad i fördelningen över kategorierna AA, AV, VA och VV för denna grupp (n=68) jämfört med samtliga elever (n=79) i varken för- eller eftertest (Chi2 test; 2*4 tabell; ns).

**Resultat**

**För- och eftertestresultat**

Hur elevernas för- respektive eftertest fördelade sig över de olika kategorierna AA, AV, VA och VV redovisas i tabell 2. Eleverna besvarar eftertestet signifikant mer vetenskapligt än förtetst (Chi2 test; 2*4 tabell; p<<0,001***).

**Tabell 2  Antalet elever i respektive kategori.**

<table>
<thead>
<tr>
<th></th>
<th>AA</th>
<th>AV</th>
<th>VA</th>
<th>VV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Förtest</td>
<td>40</td>
<td>16</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Eftertest</td>
<td>3</td>
<td>16</td>
<td>20</td>
<td>29</td>
</tr>
</tbody>
</table>

**Djupa och ytliga studiemönster**

Vid en faktoranalys skapades *djupt studiemönster* och *ytligt studiemönster*. Vid analysen utesluts fem påståenden vilket gjorde att reliabiliteten ökade för *djupt studiemönster* (10 påståenden, Cronbachs alfa 0,84) och för *ytligt studiemönster* (5 påståenden, Cronbachs alfa 0,81). Exempel på påståenden från *djupt studiemönster*:

- När jag läser något prövar jag väl digt noga om argumenten stämmer
- Kan jag finna författarens syfte med en text blir det mycket lättare att lära sig

Från *ytligt studiemönster*:

- Skall jag lära mig något måste jag satsa mycket tid på att minnas det ordentligt
- Jag har ofta svårt att se vad texten i läroboken handlar om

Samband mellan studiemönster och kategorier i eftertestresultatet 

I tabell 3 visas hur elevernas studiemönster fördelats över kategorierna på eftertesten. Bland de elever som kategoriserats till den mest vetenskapliga kategorin VV fanns signifikant fler elever med djupt studiemönster jämfört med eleverna i de tre övriga kategorierna (Chi2 test; 2*3 tabell; p=0,0075**). I förtestet fanns ingen motsvarande signifikant skillnad.

Tabell 3  Antal elever med olika studiemönster i de olika kategorierna från eftertestresultat (n=68).

<table>
<thead>
<tr>
<th>Eftertestkategori</th>
<th>Djupt</th>
<th>Neutratl</th>
<th>Ytligt</th>
<th>Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>VV</td>
<td>20</td>
<td>7</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>VA, AV, AA</td>
<td>12</td>
<td>22</td>
<td>5</td>
<td>39</td>
</tr>
<tr>
<td>Σ</td>
<td>32</td>
<td>29</td>
<td>7</td>
<td>68</td>
</tr>
</tbody>
</table>

Diskussion


References


Student teacher content knowledge of life in an aquatic ecosystem and their experience in a teaching situation – a case study

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Gustav Helldén
Maria Thomasson
Sara Wahlberg

Background
During the last decade the decreasing interest of students in science (Lyons, 2006) has caused a debate in several countries, Sweden included. The latest PISA 2006 science results also show a low interest in science among Swedish students compared to other countries (Skolverket, 2007). Furthermore, the Swedish result in science is lower compared to earlier studies with the students performing at an average level instead of higher than average. As a result, the discussion of how to develop current practice into more learning-oriented practices has been a central point in the changing of educational courses at university level for student teachers.

One of the issues in this discussion is the low quality of student teacher content knowledge, particularly at primary and lower secondary school level, as shown in several investigations (de Jong, Korthagen & Wubbles, 1998). On the other hand, Sander, Jelemenska and Kattman (2006) argue that difficulties in understanding scientific concepts arise from the difference between scientific concepts and everyday conceptions. Understanding of matter and its transformations seems to be difficult for both pupils and student teachers (Andersson, 1990; Eskilsson & Holgersson, 1999). Ekborg (2002) has shown that student teachers have problems with using scientific concepts in an applied situation, such as closed ecosystem. In order to examine the development of student teacher understanding of an aquatic ecosystem, we started an investigation into student knowledge of conditions for life and growth in a small aquarium.

Aims and framework
A new curriculum for Swedish teacher training education was introduced in 2001. To meet the new requirements, Karlstad University offers a one-year course in science, Science in everyday life, within a three-year education program. This course aims at preparing students to teach science and technology in preschool and primary school. The first part of the course is deals with ecological phenomena and the students are supposed to get a basic understanding of ecological processes sufficient enough for education at those levels. We emphasize the importance of science education already in preschool, since curiosity and interest in the subject is found at early ages (Helldén, 2005).

The aims of the present study were to:
- investigate student understanding of the conditions necessary for life in water
- trace the development of student understanding as a result of course work
- ascertain how students use their own knowledge in a teaching situation.

Methods and samples
In total, thirty-two student teachers were included in the study, which was carried out during the course Science in everyday life. This course fills the second year in the education program. In the beginning of the course, before an ecology sequence, the students were shown a small aquarium containing a plant (Elodea canadensis) and small invertebrates (Daphnia magna). The students were asked to fill in a questionnaire with questions about conditions for life in the aquarium. The student answers were analyzed and divided in to four different categories depending on how well they could explain, in a scientific way, the function of the aquatic ecosystem.

In order to get a deeper insight into student understanding of the ecological processes, two students from each category were chosen for an individual semi-structured interview. Each student was shown the same aquarium as in the pre-test and we began the interview with an open-ended question by asking the student to describe the conditions for life in the ecosystem. This was followed up with more specific questions depending on the students answers, which gave us the opportunity to elicit information that would have been difficult to gain by other methods (Duit, Treagust & Mansfield, 1996). The interviews were audio taped and transcribed verbatim.

During the second semester of the course, one student teacher carried out a teaching sequence about life in an aquarium concurrently with his school practice. This was video-recorded, transcribed and analysed in order to see how the student developed a teaching situation and used the knowledge acquired during the ecology course. The student was then interviewed about his teaching while watching the video clip (stimulated recall).

At the end of the second semester, all the students were given the same questionnaire about life in water as in the beginning of the course. The same four categories were used and answers were divided accordingly to see if any movement between categories had arisen.
Finally, all students were divided randomly into four groups for a last field exercise at a pond. Each group was asked to
gather plants and animals to construct a complete mini-ecosystem in order to prepare a model field excursion with a
class of children. The constructing activity and the discussions that arose were video-recorded for further analysis.

Results
According to the results of the first questionnaire, four different categories were defined with an increasing
understanding of the function of the ecosystem from category one to four. In the first category, students mentioned
that plants and animals needed oxygen and nutrients for living but no one thought of carbon dioxide as a component
of the cycle of matter. Students in category four could more completely explain the function of the ecosystem and also
included the energy concept but full understanding was still not achieved. The number of students in each category
(from 1 to 4) were fourteen, eight, six and four respectively. When analyzing the results from the second questionnaire,
the same four categories were used there was no need for adding a fifth category for higher understanding. The
numbers in each category (from 1 to 4) were nine, nine, eleven and three respectively.

The interviews revealed that most of the students believed that their knowledge in ecology had increased and
developed during the course. Generally, their understanding of cycles of matter and the basic function of an ecosystem
was poor, especially about processes specific for an aquatic ecosystem. Most students had problems with explaining
occurrence and circulation of gases. None of the students mentioned that plants also respire.

The students also had difficulties in explaining the concept of nutrients. They all emphasized the importance of nutrients
but could not really explain what they were or where they came from:

All living things get nutrients from each other.

The video-recording and the stimulated recall of an authentic teaching situation showed that the student teacher
had good contact with the children but that he repeatedly lost track. Several situations also showed that the student
teacher missed important questions and statements from the children which he was not aware of during the lesson but
first realized when he saw the film. In the following example, there is no discussion about the greenhouse effect or the
necessity of the sun for photosynthesis:

Pupil: It does not matter if we turn off the sun. It will be warm anyway due to all greenhouse gases.
Student teacher: It will be warm anyway, yes, but there is no…
Pupil: Light
Student teacher: If you have any more questions you can ask.

This difficulty in following up discussions and questions in the classroom might be due to not paying attention to the
children and/or poor content knowledge. The student teacher himself thought of stimulated recall as a strong tool for
improving teaching skills.

Conclusions and implications
The present results show that many student teachers in this case study had a quite limited understanding of conditions
for life for animals and plants in a water ecosystem, especially concerning the resources in a gaseous state. Thus, there
is a need for developing a teaching strategy in teacher education where a student teacher’s own ideas about the
phenomena are challenged to a greater degree. Student teachers should also be given opportunities to discuss their
ideas in relation to scientific explanations, as described by Ekborg (2005).

References
53-85.
conceptual change. In B. J. Fraser & K. G. Tobin (Eds.), International handbook of science education (pp. 745-758).
learning in science and mathematics. In R. Duit & B. J. Fraser (Eds.), Improving teaching and learning in science
grundskollärarprogrammet utvecklar för miljöundervisning relevanta kunskaper i naturkunskap. Göteborg: Acta
Universitatis Gothoburgensis.
Science Education, 27(14), 1671-1694.
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Understanding scientific concepts


**Student teacher use of communicative support to make meaning of abstract phenomena in the content area of energy**

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**Background, aim and framework**

This study aims to describe the strategies which student teachers in science use to communicate their associations of energy with other concepts. The point of departure is that the students use all their resources in their meaning-making process, including practical and theoretical experiences. As we are trying to understand something that is new to us we transfer meaning from an already understood situation with which we are familiar (Dewey, 1910/1991).

Things familiar to us, that have an obvious meaning, are defined by Dewey as *concrete*. As we are dealing with *abstract* things we have to recall something familiar to us and thereby translate from abstract to concrete to be able to grasp the meaning of the abstract thing or term. As an example, Dewey discusses the term *atom*, which to someone familiar with natural science could be concrete, whilst to a beginner the term is abstract. The novice first has to recall something more familiar to him/her and through a slow process of translation come up with a meaning of *atom*. Concrete and abstract thinking is thus personal. In science, symbols or terms stand for a certain meaning. Dewey claims that it is necessary to experience some situations where these meanings are actually significant to make these symbols stand for specific meanings for any individual. Words get their true meaning as we interact with things (Dewey, 1910/1991).

The concept of energy is an abstract term to many students. Research has shown that energy is hard to grasp (Carlsson, 2002; Kruger, 1990; Watts, 1983). To communicate energy as an abstract concept, we need some kinds of strategies or linguistic tools, here called *communicative support*. Roth and Lawless (2002) argue that scientific language develops in different steps. The novice uses "muddled" talk accompanied by deictic expressions and iconic gestures and later a more abstract way of communicating develops. This study aims at scrutinizing what kind of verbal communicative support student teachers use as they associate the concept of energy with other concepts and at describing the ways in which communicative support is used.

**Methods and sample**

Three natural science teacher students were selected for interviews. The students were enrolled at a university in a the teacher training program for Swedish primary school (school year 1-7; pupils aged 7-12 years). Each student was interviewed twice during the second semester of science studies. The first interview was before and the second after four weeks of teaching practice. During the teaching practice the students taught the content area of energy; more specifically they worked with energy from a food perspective, namely, why we eat and what happens to food as we eat. They also focused on which foods are healthy and which are not and why we have to exercise in order to stay fit. Nicolas spent his teaching practice in school year five and the pupils were about 12 years old. Madeleine was in a mixed age class with pupils from school year 1-4 and the pupils were 7-10 years old. Susanne’s pupils were about 8 years old as she spent her teaching practice in school year two. The student teachers had studied metabolism and photosynthesis in a previous course.

The interviews were carried out using the ‘association tool’ (Stolpe & Stadig Degerman, 2008). The association tool is a way to study associations of a specific concept, in this case *energy*. In both interviews the students were asked to clarify their associations of energy in two different ways: firstly they had to come up with concepts appropriate for explaining energy to a peer; secondly to their pupils. The students were requested during this work to explain their associations and they were challenged by questions like ‘Could you explain this further?’ or ‘Why is it like that?’ The interviews were video taped and then transcribed verbatim.

The transcribed interviews were read through to identify strategies used by the students to make meaning in the content area of energy. Two different strategies were found; within the first strategy the students used their own experiences and in the second the students used a causal chain of events. This paper reports on the students’ own experiences and what kind of experiences these are.
Results
When a scientific phenomenon is exemplified by everyday life events, experiences, phenomena or technology it is here categorised as Examples from everyday life. The use of everyday life examples is the most common strategy used by the students to make meaning of energy. As Nicolas is trying to see a connection between force and energy he is using hydroelectric power as a technical example to sort out the concepts. He states: Because the energy in the water flow which… you know, drives a turbine which develops a force which then generates electricity which may be able to perform work. The use of a concrete example helps Nicolas to communicate the abstract connection between force and energy to the interviewer.

Examples from science is defined as typical examples used in science to explain an abstract scientific phenomenon. In this case other scientific theories are used to explain a certain phenomenon. Examples from science are much less common as strategy than examples from everyday life among these students. Nicolas and Susanne both use this strategy in the first part of the second interview. The use of this strategy is initiated by a request from the interviewer to give an example. Susanne uses her knowledge of the processes in the body to exemplify work and the notion that energy loses quality as it transforms. She claims that energy is needed to do work, which triggers the interviewer to ask her to exemplify what she means by work and she answers: For example that the energy in the body, in the cells, makes it work, processes, and then loses, when it starts. It makes us manage to keep up the processes in the body, but then it will lose quality.

A statement is categorised as Examples from own studies of science when the student uses examples from experiments, lectures, peer discussions, course literature and other specific examples from their own education in science, and in some way give a clue from where the example originates. All three students use examples from their own experiences of science in the second interview, but not in the first. Madeleine refers to the science course as she is trying to distinguish if there is a difference between energy and nutrition. At first Madeleine says that nutrition and energy may be the same, but then she recalls something said on the course she has taken. Communicative support thus helps her to conclude that nutrition and energy are not the same.

The students used communicative support to a greater extent after the four weeks of teaching practice than before.

Conclusions and implications
The experiences used by the student teachers could be categorised into three different categories: examples from everyday life, examples from science and examples from own studies of science. Of these three the first one was the most common and it was spontaneously used by the students, that is, without being stimulated by a specific question from the interviewer. Examples from science were only used when the interviewer asked for an example. Communicative support may help the student to change standpoint, as in the case of Madeleine. Thereby communicative support could be both a facilitator of communication as well as support for the student’s own learning.

The results show that the students use resources from their own experiences to communicate an abstract phenomenon like energy. In Dewey’s (1910/1991) terminology they use concrete examples to explain abstract things. Experiences as communicative support may be one step to develop the scientific language using the iconic gestures suggested by Roth and Lawless (2002), “muddled” talk and deictic expressions. Communication support could be one way to develop quality of the scientific language among students.

Teaching practice could be used to practice the use of communicative support, which is underlined by the fact that the students use it to a greater extent after teaching practice than before. The influence of teaching practice could be further investigated in future studies.

References
Student teacher conceptions of matter and substances - some results from 31 interviews
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Background, aims and framework
Some topics in introductory chemistry seem to be a worldwide problem that researchers have wrestled with for many years (Andersson, 1990; de Vos & Verdonk, 1985; Johnson, 2000b; Nakhleh, 1992). The particulate view of matter was early singled out as a key problem (Nakhleh, 1994; Nussbaum & Novick, 1981), in addition to chemical reactions (Andersson, 1990; de Vos & Verdonk, 1985; Johnson, 2000b), phase changes (Andersson, 1990; Stavy, 1990; Stavy & Stachel, 1985) and the gaseous state (Johnson, 1998a; Stavy, 1988).

Recently two concepts that are perhaps even more fundamental, have been added to the list: the concept of matter (Nakhleh, Samarapungavan & Saglam, 2005; Stavy, 1991) and the concept of a substance (Johnson, 1996; 2005). An interesting aspect in this connection is Johnson’s (1998a; 2002) findings that some understanding of the particulate view of matter seems necessary to understand all these key concepts and vice versa.

A key concept within human constructivism (Ausubel, Novak & Hanesian, 1978; Novak, 1993) is meaningful learning. New concepts always have to be tied to existing concepts in the learners’ cognitive structure. Teachers with this view of learning and teaching would claim that it is important to know something about the prior ideas of students. Only then one can pick out the “relevant anchoring concepts available in the learner’s cognitive structure” (Ausubel, Novak & Hanesian 1978, p. 358) and make teaching meaningful.

The aim of this investigation was to find out what Norwegian student teachers think about matter and substances and to what extent they use a particulate view of matter when they try to explain phenomena. The research question therefore was:

• To what extent do student teacher views of matter and substances differ from the scientific view, and is it possible to find any common relevant anchoring concepts for introductory chemistry education?

The concepts of matter and substances are used from day one in chemistry teaching. A teacher wrongly assumes that the students understand and use these key concepts scientifically; there is most probably a crucial communication problem (Johnson & Gott, 1996). For students that use these concepts differently, major parts of the chemistry teaching must be a mystery, and they are left with only one option: rote learning.

Methods and samples
Science is not a compulsory subject in Norwegian teacher education. At University of Stavanger the student teacher can choose to include 30 + 30 credits (ECTS) science as part of their education. Introductory chemistry (10 ECTS) is one module within this science education. It is reasonable to assume that it is the students who are more interested (and able) in science that choose these courses.

In all 31 students were interviewed before they started the introductory chemistry course. The interviews were semi-structured and linked to practical tasks. All interviews were tape recorded and some photos were taken.

In 31 student interviews were used. The students were initially introduced to a selection of 29 different objects, and asked to sort them as they wished. They were asked if they could see anything the objects had in common and comment on that. Later eight single-substance objects were picked out and students were asked if they could see anything in common to these and comment on that.

The students were then asked to explain the results and what had happened to the substances in five practical demonstrations: evaporation of water, the missing stearin of half burnt candles, formation of dew (water), melting of stearin and dissolving of coarse salt in a glass of water. The interviewer consistently tried to avoid any expression that could hint at what had happened to the material.

The interview was finished with a discussion of the meaning of some Norwegian words: “stoff” (stuff/matter) and “materiale” (materials), the borderline between “stoff” (stuff/matter) and not “stoff” and the difference between “enkeltstoff (reint stoff)” (a substance) and “stoffblanding” (a mixture).

The interesting parts of the interviews were partly transcribed. The results were coded, sorted and analyzed.

Results, conclusions and implications
Three main aspects will be discussed: the two concepts matter and substance, and the particulate view of matter.

In classical science, there is a strict borderline between what is material and what is not material (Chi, Slotta & Leeuw, 1994). This investigation revealed several non-scientific views of matter. A few examples: Only a few students could
see anything common to all the objects to be sorted. Statements like “different substances” or “built from atoms” were mentioned. Some claimed that the missing stearin had become energy, light or heat, and for some it had just disappeared. Others had no explanation for the dew outside the glass of water with ice cubes. About 1/3 of the students did not conserve mass (weight) during the dissolving process and/or melting process.

When asked directly about the borderline between matter (“stoff”) and non-matter (“ikkkestoff”), six students thought only of solids as matter/stuff (“stoff”). Another four included the liquids but not the gases. Three did not include natural or living things among matter/stuff. In total 21/31 students had one to several views on matter (“stoff”) that did not correspond to the scientific view. It is interesting to notice that these findings correspond well with Stavy’s (1991) results for children grade 1-7.

In Norwegian the same word, stuff (“stoff”), is used both for the general term matter and for substances. The idea of single substances, with their own identity and their own properties, is, however, crucial for the understanding of chemistry (Johnson, 2000a). It is especially important in connection with reactions.

Although all students seem to recognize, use, buy and sell different substances, and are certain they will remain unchanged if treated properly, most students seem to have a rather vague notion of what a substance really is. When asked if they could see anything common to the eight single-substance objects, only one eventually recognized that they all were pure substances. When asked directly about the expressions: a (pure) substance (“enkeltstoff/reine stoff”) and mixtures (“stoffblandinger”), 13/31 expressed views that were scientifically (more or less) correct. But when it came to evaporation, burning of candles and formation of dew, only four of them gave explanations that show that they had reasonably good notions of substances. 16/31 thought that a single (pure) substance was one that contained only one element (“et grunnstoff”). Their different notions agree well with Johnson’s (2000a) work that shows that “children do not ‘naturally’ have a concept of substance identity . . . .”.

This investigation had no task or questions that directly probed student understanding and use of the particulate view of matter. Instead we noted how the students spontaneously used these ideas during the interview. None of the students gave explanations that revealed anything near a complete (basic) particulate view of matter. As many as 25/31 students, however, sporadically mentioned some sort of particle (molecules, atoms, small piece, particles), in a relevant way, one time or more in their explanations. It was most often mentioned in connection with the solution of salt (21/31) and evaporation of water (10/31). Only four students used some sort of particles relatively consistently across more tasks (four-eight times). This agrees well with Johnson’s (1998b) and Nakhleh’s et al. (2005) observations that students seldom use particles spontaneously when they talk about substances.

Summing up the three main aspects discussed, 28/31 students either had some kind of view of matter and/or substances deviating from the scientific one or they used ideas about particles only sporadically. In other words, these basic and fundamental concepts in chemistry seem to be rather poorly understood among our students. As our students most probably are among those who are more interested and able in science, this probably also holds true for more Norwegian student teachers in teaching and learning situations. Assuming that these concepts are well understood must generate many problems. For many, their only option must be rote learning (Ausubel, Novak & Hanesian, 1978).

This investigation has uncovered a wide range of non-scientific ideas about matter, substances and the use of the basic particulate view of matter. These key concepts therefore clearly need to be addressed as part of introductory courses in chemistry. Common and relevant anchoring concepts, however, seem to be rather limited. As all students recognized solid substances as matter, this could be used as one common starting point. By consolidating and expanding the concept of substances the concept of matter can also gradually be expanded. As some understanding of the particulate view of matter seems necessary to understand these key concepts (Johnson, 1998a; 2002), the particulate view of matter must be taught simultaneously. As many students spontaneously introduced some sort of particles in their explanation of the dissolving of solid matter (salt) in water, this might be used as a starting point.

These anomalous ideas about matter, substances and the particulate view of matter must also generate problems in part of the biology and ecology education, such as physiology, and circulation of nutrients.

References


Mängtydigheten hos begreppet temperatur

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Inledning


När det gäller det fysikaliska begreppet temperatur finns en begreppslig substruktur som har sina specifika referenter. Några lärarboksförfattare på högskolenivå tar hänsyn till detta (Schroeder, 2002). Genom att intervjuar doktorander inom fysik, kemi och biologi samt lärare och lärarkandidater inom naturvetenskap om temperaturbegreppet vill vi bidra med nya perspektiv och nya idéer till forskningen om naturvetenskapliga termers semantik och semiotik samt bidra med nya perspektiv på begreppslig förändring ('conceptual change').

Metod

Det empiriska datamaterialet härör från en tidigare studie (Jeppsson & Strömdahl in.prep).

Respondenter

Två lärare inom naturvetenskap (L1, L2; en matematik- och fysiklärare samt en kemi- och naturkunskapslärare), fyra lärarkandidater för gymnasiet (LK1….LK4, inriktade mot matematik, naturkunskap, kemi och fysik) samt fyra doktorander (D1….D4, med inriktning mot fysik, kemi och biologi) har intervjuats individuellt. Urvalet har styrts av tillgänglighet av intervjupersoner. Ett uppföljande seminarium genomfördes med de fyra lärarkandidaterna. Både intervjuer och seminarier videoinspelas. Intervjuerna bestod av två delar, en del där respondenterna muntligen fick lösa en termodynamisk uppgift som presenterades i skriftlig form. Den andra delen var av semistrukturerad karaktär där det var...
respondenternas idéer om temperatur som var i fokus och bestämde riktningen för intervjun (Kvale, 1997). I seminariet ombads respondenterna först att skriva ned vad de tänkte på när de hörde ordet temperatur både spontant och i en naturvetenskaplig kontext varpå en diskussion skedde om detta samt en uppföljande diskussion om uppgiften som presenterats i intervjun.

**Analyserverktyget**

I den semiotiska triangeln (Figur 1) beskriver relationen mellan symbol/ord, begrepp och referent. Symbolen/ordet i sig är godtyckligt medan begreppet är en modellering av referenten som i sin tur är en avgränsad del av ett fenomen i omvärlden.

**Figur 1** Den semiotiska triangeln enligt (Jfr Ogden & Richards (1989/1923).

I 2-D SAS (Figur 2) som är utvecklad av Strömdahl (submitted), är triangeln utsträckt (horisontellt) och kompletteras med en vertikal axel där man tar hänsyn och visar på mångtydigheten hos ordet som är i fokus. I detta fall temperatur.

**Figur 2** Mångtydigheten hos ordet temperatur.

Temperatur kan behandlas på en rad olika nivåer och det finns många föreställningar om begreppet som inte stämmer överens med den vetenskapliga definitionen. Inom naturvetenskaplig didaktisk forskning är det välkänt att många elever har ’misconceptions’ eller ’everyday-knowledge’ om temperatur (Carlton, 2000; Ericksson, 1979).

I 2-D SAS (Figur 2) benämns dessa som Non Formal Concepts’ (C_{NF}) som i sin tur beskriver Non Formal referents’ (R_{NF}). Då dessa icke formella begrepp och deras referenter utgör en mängd, markeras de med en mängdklammer, {}. Det fysikaliska begreppet temperatur kan beskrivas kvalitativt (C_{SP}) som kinetisk medelenergi för partiklar i ett system och matematiskt (C_{PQ}) partiella derivatan \( T = \left( \frac{dU}{dS} \right)_V,N \) (\( T = \) temperatur, \( U = \) inre energi, \( S = \) entropi, \( V = \) volym och \( N = \) partikelantal) alternativt inom den statistiska termodynamikn kan den identifieras som en

1. Icke formellt begrepp i förhållande till ett naturvetenskapligt perspektiv
2. Icke formella beskrivningar av fenomen ute i verkligheten (referenter) som inte stämmer överens med ett naturvetenskapligt perspektiv för det aktuella ordet.
3. Begreppet för det fysikaliska fenomenet
4. Begreppet för den fysikaliska storheten
Lagrangemultiplikator vid bestämningen av Boltzmanfördelningen i den kanoniska ensembler av partiklar i ett system. Oavsett begreppsbildningen utgör referenten partiklar och deras rörelse. Man kan även rent empiriskt tala om temperatur (\(C_{\text{PQ,empiri}}\)). Det empiriska begreppet temperatur refererar till en enhet (1 °C, 1 Kelvin) och mätning med ett mätningstillverk, t.ex. en termometer.

**Resultat**

I studien Jeppsson & Strömdahl (in prep.), fick respondenterna som en del i intervjun fundera och resonera runt en speciell termodynamisk uppgift. En av lärarna (L2) beskrev temperatur enligt följande:

Excerpt 1 (L2)

L1 om du skriver ordet temperatur, om jag säger ordet, vad tänker du på då?
L2 då skulle jag säga varmt å kallt … så där rent spontant … det är ju så vi vardags språk refererar till temperatur
I1 ja ha … om du sen skulle behöva prata om temperatur med en kollega som är inom samma … någon slags vetenskaplig temperatur … vad skulle du säga då?
L2 ja det är ju kopplat till rörelse i atomen och molekylen men … jag faktiskt inte rent fysikaliskt hur man uttrycker temperatur
I1 nå, … om jag säger värme då, om vi skulle göra samma sak för värme vad tänker du då?
L2 rörelser i atomer och molekyler
I1 mm
L2 skulle jag uppvisa det som
I1 tycker du dom två är samma sak, temperatur och värme?
L2 nej jag använder ju inte uttrycken på så sätt… jag pratar ju inte om någon slags rörelse i atomer och molekyler när jag skall prata om temperatur

På liknande sätt uttryckte sig de flesta lärarkandidaterna och doktoranderna när de skulle beskriva begreppet temperatur. Det var bara D1, D3 samt LK4 som beskrev temperatur i termer av medelenergi, medelrörelse hos molekyler, etc.

Utifrån den givna uppgiften i intervjun som gäller temperaturfördelningen mellan två behållare med ideal gas A och B där B innehåller dubbbla partikelantalet jämfört med A men med samma totala inre energi resonerar LK4 på följande korrekt sätt:

Excerpt 2 (LK4)

LK4 Man skulle kunna säg något om att energin i B är fördelad på dubbelt så mycket materia som i A och då kan man säga. därför kommer väl medelhastigheten hos en partikel i A vara högre en medelhastigheten hos en partikel i B därför att det är halften så många partiklar i 2 kg som flyger omkring och därför att det är halften så mycket energipartiklar per partikel så att då flyger de mycket snabbare. Så att då har vi egentligen dubbelt så hög temperatur i A som i B ……borde det ju bli så att…när man sätter dem i termisk kontakt måste temperaturen i A sjunka och temperaturen i B öka.

I det uppföljande seminariet med lärarkandidaterna ombuds de att individuellt skriva ner sina spontana tankar kring ordet temperatur. I tabell 1 sammanfattas utfallet. I Tabell 2 sorteras lärarkandidaternas uppfattningar med avseende på deras plats i 2-D SAS.

**Tabell 1** Sammanställning av de olika lärarkandidaternas (LK) beskrivning av temperatur.

<table>
<thead>
<tr>
<th>TEMPERATUR</th>
<th>LK1</th>
<th>LK2</th>
<th>LK3</th>
<th>LK4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ett mått (tillsånd) för intern energi</td>
<td>Termometer</td>
<td>Bada bubbelbad</td>
<td>Värme</td>
<td></td>
</tr>
<tr>
<td>Dimensionslös</td>
<td>Fahrenheit</td>
<td>Termometer</td>
<td>Tryck</td>
<td></td>
</tr>
<tr>
<td>Känslor</td>
<td>Celsius</td>
<td>Fahrenheit</td>
<td>Rörelser</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grader</td>
<td>Celsius</td>
<td>Medelvärde</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Värme</td>
<td>Kelvin</td>
<td>Celsius</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kyla</td>
<td>Rumstemperatur &gt; 20</td>
<td>Kelvin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storhet med SI-enhet</td>
<td>Fahrenheit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5 Fysikalisk storhet för det vi mäter med exempelvis en termometer
Tabell 2  Fördelning av lärarkandidaternas uppfattningar i 2-D SAS.

<table>
<thead>
<tr>
<th>TEMPERATUR</th>
<th>Non Formal</th>
<th>Fysikaliskt Fenomen (SP)</th>
<th>Fysikalisk Storhet (PQ)</th>
<th>Empiriskt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rörelse</td>
<td>Bada bubbelbad</td>
<td>Storhet med SI-enhet</td>
<td>Celsius</td>
<td></td>
</tr>
<tr>
<td>av rörelse?</td>
<td>Känslor</td>
<td></td>
<td>Kelvins</td>
<td></td>
</tr>
<tr>
<td>Fahrenheit</td>
<td>Värme (2 ggr)</td>
<td></td>
<td>Fahrenheit</td>
<td></td>
</tr>
<tr>
<td>Termometer (2ggr)</td>
<td>Kyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rumstemperatur &gt; 20</td>
<td>Tryck</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Slutsatser och implikationer
Styrkan i 2-D SAS ligger i hur väl man kan strukturera ett ords mångtydighet. Som resultaten visar finns det många sätt på hur man kan tala om temperatur. Flertalet betydelser av ordet har icke formell karaktär och faller inom ramen för mängden (NF).

Analysen beskriver på ett explicit sätt mångtydigheten i två dimensioner hos ord som används i både naturvetenskapliga och vardagliga sammanhang och skapar därmed förutsättningar för en detaljerad analys av orsakerna till missuppfattningar och alternativa uppfattningar. Detta ger implikationer för att utforma undervisning när syftet är att fokusera på den naturvetenskapliga betydelsen av ett ord, i detta fall temperatur.

References

Referent change, a neglected aspect in traditional conceptual change approaches to science learning and teaching
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Introduction
It is a well documented fact that words imported from non-formal everyday language, and used as defined terms in formal scientific language, make up a challenge in both teaching and learning. The extensive research on learners’ conceptions of scientific concepts is a salient exponent of that fact (Duit, 2008). For instance, the foundational scientific terms force, temperature, electric current, heat and energy are found to be difficult to attain among learners both at elementary and advanced levels. Even science teachers in secondary schools have shown deficiencies in their ability to define such terms (Galili & Lehavi, 2006).

In science educational research, learning scientific terms is generally treated as a process of conceptual change. In the standard approach the learner is supposed to make a cognitive transition from a pre-instructional conception of a natural object or phenomenon to the current scientific concept (Duit, 2003). In Figure 1 this approach is illustrated by the conceptions and concept of temperature.
The set \( \{ cc_1, cc_2, cc_3, \ldots, cc_n \} \) denotes ‘conceptual change’ – theories aiming at identifying the educational conditions for the transition from a non-formal conception to the formal (scientific) concept.

However, starting from a semiotic/semantic perspective the word ‘TEMPERATURE’ expands a ‘sense-spectrum’ (Cruse, 1986, p. 71-74), a space of meaning, simultaneously including the common parlance meaning or, more correctly, a set of non-formal meanings ((NFI)), TEMPERATURE and the scientific meaning enclosing the current delimited qualitative scientific phenomenon (SP), \( \text{TEMPERATURE}_{\text{sp}} \), the physical quantity (PQ), \( \text{TEMPERATURE}_{\text{pq}} \), and the operationalization meaning a measurement \( \text{TEMPERATURE}_{\text{pq,emp}} \). Additionally these senses could be analysed in the dimension of the semiotic properties of symbol, concept and referent. See Figure 2 for the complete two-dimensional analysis, 2-D-SAS (Strömdahl, in prep.), making the properties of a term like TEMPERATURE explicit, thus opening up for consecutive discernments of critical features in the meaning making processes and thereby also revealing the conceptual complexity involved in the attainment of scientific knowledge. For more details see Strömdahl (in prep.).

**Figure 1** The standard conceptual change approach.

**Figure 2** The two-dimensional analysing schema, 2-D-SAS applied to temperature.

C and R denote concept and referent respectively. rC1 and rC2 indicates relationships (r) between concepts and rR1 and rR2 between referents (from Strömdahl, in prep.).

**Aim**

There is a spectrum of educational implications from the application of the 2-D-SAS approach. However, here I will just briefly explicate the role of identifying the referent as a base for conceptual modelling/change by discerning and comparing the referents of HEAT and TEMPERATURE.

**Analysis**

In Figure 2 the non-formal \( \text{TEMPERATURE}_{\text{NFI}} \) is differentiated in a set of non-formal concepts \( C_{\text{NFI,temp}} \) (generally denoted as misconceptions or alternative conceptions) comprising ideas of warmth and cold and a set of corresponding referents \( R_{\text{NFI,temp}} \), bodily experiences of events relating to these ideas. In a similar schema for \( \text{HEAT}_{\text{NFI}} \) we would find \( C_{\text{NFI,heat}} \) and \( R_{\text{NFI,heat}} \).
and $R_{\text{NFheat}}$ more or less overlapping the same concepts and referents as for TEMPERATURE$_{\text{NF}}$. This last statement is empirically proven by previous research reporting on the mix-up between heat and temperature (Duit, 2007; Tiberghien, 1983; Kesidou, Duit & Glynn, 1995; Wiser & Amin, 2001). In non-formal situations this mix-up of non-formal senses is no obstacle for proper everyday communication and actions. Similar non-formal ideas have also been a starting-point for finding out the nature of warmth and cold in the history of science. However, by painstaking efforts, classical thermodynamics has ended up attaching the word TEMPERATURE to the property of everything that follows the zeroth law of thermodynamics (in Figure 2 denoted as the concept $C_{\text{SPtemp}}$): "If two bodies are each in thermal equilibrium with a third body, then they are in thermal equilibrium with each other." If the third body is a thermometer its readings will have physical significance. The bodies with these properties are the referent $R_{\text{SPtemp}}$ of the concept $C_{\text{SPtemp}}$. From a more general phenomenological point of view, within kinetic gas theory, $C_{\text{SPtemp}}$ can be looked upon as the "intensity of the motion" (mean translational energy) among the molecular/atomic particles. Thus, the referent $R_{\text{SPtemp}}$ is a special aspect of molecules and atoms and their motion. In this paper I leave out the more theoretical and statistical mechanical interpretations that are possible.

The quantitative aspect of temperature is expressed by $C_{\text{PQtemp}}$ which is a base physical quantity belonging to the coherent system of physical quantities within the International system of physical quantities and units, SI, and the mathematics of quantity calculus. It is operationalized by the definition of a unit (1 K) for temperature, the empirical quantification of measurement $C_{\text{PQempir temp}}$ connected to the referent of readings of a measuring device $R_{\text{PQempir temp}}$, here thermometers.

Heat, on the other hand is in science referring to the process of energy transfer between two bodies of different temperature, referent $R_{\text{SPheat}}$. It is another aspect of atomic/molecular motion than temperature. The physical quantity $C_{\text{PQheat}}$ and its quantification $C_{\text{PQempir heat}}$ (SI unit 1 J) has the same dimension as energy and is connected to the referent $R_{\text{PQempir heat}}$, the operational measuring by e.g. a calorimeter.

If we are just looking at the problem of separating the senses of the scientific terms heat and temperature there is no possibility to remain within the sets of non-formal referents $R_{\text{NFtemp}}$ and $R_{\text{NFheat}}$. From the 2-D-SAS analysis it is clear that to learn the scientific concepts heat and temperature one must explicitly identify the correct referents since they are the base for the conceptual modelling. Conceptual change is not possible if the referent of the target concept is not the correct one. To make these statements more tangible, an excerpt of 2-D-SAS schemas, where only the referents of heat and temperature are displayed (Figure 3), we can see the impossibility of building on the empirically found referents in the non-formal approach, since they are mainly based on bodily experiences of thermal character and are overlapping. The formal senses of the scientific concepts of heat and temperature must build on the formal referents. Thus they have to be identified as necessary conditions in the process of conceptual attainment. In traditional conceptual change this referent change is not made explicit.

![Figure 3](image-url) The referents of the scientific terms of heat and temperature, to be separated from non-formal referents and each other as a base for the process of concept modelling.
Conclusion and discussion

Most research on student conceptions (alternative conceptions or misconceptions) and teaching and learning science concepts is framed by different conceptual change theories. The present investigation starts from a semiotic/semantic perspective by introducing the 2-D-SAS approach expanding a space of meaning, a ‘sense-spectrum’ of a term connected to the term’s semiotic properties as symbol, concept and referent. In this paper the focus is on the importance of identifying the referent as the basis for modelling the concept. This is illustrated by eliciting the well known learning difficulties of attaining the scientific terms of heat and temperature. The educational value of the 2-D-SAS approach analysis is to stress the polysemy, the space of meaning, the ‘sense-spectrum’ of terms in a way that makes it possible to discern the critical features identifying the intended learning object, here exemplified by the scientific referents of TEMPERATURE and HEAT. Subsequently, in learning the scientific meaning of terms, the demand put on the learner and the teacher is to discern these categories of semantically distinct meaning and referents of the one and the same polysemous word and to disambiguate the term according to context.

The approach is applicable to any term to sort out its scientific significance and its category membership. Compared to the common conceptual change research in science education on attainment of scientific terms, the 2-D-SAS approach adds among other things the neglected explicit aspect of referent change.

References


Planning science instruction:
From insight to learning to pedagogical practices

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The quality of memorable episodes in science education
Ola Magntorn ola.magntorn@hkr.se

Background, aims and framework
This is the third part of a sequence of studies dealing with the developing abilities to read nature in relation to a teaching sequence in a primary school class. In the first part the primary school class (10-11 years) was followed during a teaching sequence and their developing ability to read nature was analysed and evaluated (Magntorn & Helldén, 2007). This was followed by an analysis of the views of experienced teachers on the teaching sequence in relation to its possibilities and limitations for implementation in everyday school activities. The aim was to elicit critical aspects supporting or hindering the implementation of such a teaching design in the everyday teaching activities (Magntorn & Helldén, 2006).

This third study is a stimulated recall study where the students were interviewed 18 months after instruction. The focus lies on what types of facts and episodes they recall.

In a large review on research on outdoor learning Rickinson et al. (2004) claim that:

… fieldwork can have a positive impact on long term memory, due to the memorable nature of the fieldwork setting and there can be reinforcement between the affective and the cognitive, with each informing the other and providing a bridge to higher order learning. (p. 32)

As anyone with some teaching experience is aware of there is no given causality between hands-on activities and successful teaching. The focus of interest is the quality of the events leading to long term retention of episodes and knowledge.

The research question is:

What is it that the students can remember 18 months after instruction and are there any qualitative patterns of resemblance between the facts or the episodes they recall?

The ability to read nature is central in this work. It is described in Magntorn & Helldén (2005), but needs a brief explanation here as well. It has to do with an ability to recognise organisms and relate them to material cycling and energy flow in the specific habitat that is to be read. It has to do with the natural world that we face outside, and the tools we have are our experiences from previous learning situations, both in and out of doors. In this case it has to do with student ability to give a relevant interpretation of the river as an ecosystem based on recognition of common organisms and awareness of their autecology together with an understanding of the relationships between functional groups and how abiotic factors, such as light and water velocity, influence the whole ecosystem.

Methods and samples
The overall teaching sequence comprised four phases spanning seven lessons of varied duration from 80 to 200 minutes (Figure 1). The teaching had a bottom-up design starting with a focus on a single organism, a freshwater shrimp, and ended with a systemic view of the whole river. The researchers were not involved in the instruction. For reasons of transparency and hopefully of interest to the reader, a 40 minute film covering the sequence is now available on: mms://194.47.25.160/mna/vramsafilmen.wmv

<table>
<thead>
<tr>
<th>Hands-on activities during the teaching sequence</th>
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<td><strong>Phase 1:</strong> <em>Collect and study the freshwater shrimp and its ecology</em>&lt;br&gt;<em>Feeding experiment (litter bags)</em></td>
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**Figure 1** The teaching sequence spans from February until May and the different phases represent the progress of the learning events
Ten of the 22 students did a follow-up interview 18 months after the teaching sequence. These ten students were selected as representing three groups: good readers of nature (four students), three average students and three poor readers. The underlying data for this selection were their levels of reading nature according to the SOLO-taxonomy (Biggs & Collis, 1982) presented in an earlier paper (Magntorn & Helldén, 2007). The interviews were open-ended with a standard first question where the interviewer asked the students to say what they remembered from the teaching sequence. The interview is a type of stimulated recall technique where the researcher, who was passive but present during instruction, can be regarded a cue for recalling the events the students went through. Stimulated recall is a method to revive the memories of students after a class in order to recall the thoughts that occurred during it. The basic idea behind the use of stimulated recall is that a subject may be enabled to relive an original situation with great vividness and accuracy if he is presented with a large number of cues or stimuli which occurred during the original situation” (Haglund, 2003). During the interview the students were also asked to look at authentic objects from the river and to say as much as they could remember about their ecology and/or relations to the ecosystem.

Results
The data shows that some events are recalled by all the students whereas some events are only mentioned by a minority of the students, if at all (Figure 2). Also interesting is that the episode that came first to mind by all the students was when they constructed a sealed aquatic ecosystem, like an aquarium but with a tight lid and no oxygen pump. The second most frequently mentioned episode was when the students did an experiment on the food preferences of some animals in the river. Another aspect from this metacognitive study was to see which organisms they could identify compared to their earlier interviews where all students could identify at least seven different organisms (Magntorn & Helldén, 2007).

Regarding the organisms, the freshwater shrimp was the key organism in the study and it is therefore no surprise that they all identify this animal (Figure 3). The same thing goes for the freshwater louse where the students relate it to the litterbag experiment. The caddis fly larvae are what they relate to the test about adaptations to fast and slowly running waters. The dragonfly larvae and the salmon were the examples used to describe the different levels of the food-pyramid together with the shrimp.

Interestingly, many students remember the leach although it has not been part of any of the experiments. It has however an interesting biology and some species are blood-suckers.
Again we have links between the episodes and the recall of the specific organisms linked to these episodes. Other animals, and not least plants, have been very common and studied several times during the sorting of organisms but no students or very few students recall these organisms.

**Conclusions and implications**

The response from the students support a study by Mackenzie and White (1978) who postulate that recall of any element is a function of its degree of interlinking in memory with other elements. As a specific instance, newly acquired verbal knowledge and intellectual skills will be retained better if it is associated with easily recalled episodes. In this study the students spontaneously mention episodes in the first place. The episodes best recalled have one or several of the following criteria in common:

- The event challenges everyday concepts or beliefs. This is particularly obvious in the closed ecosystem experiment which challenged student ideas about cycles of matter in living systems
- The students become an active part of the scene rather than observers of it
- The students generate information themselves rather than receive it
- The students see a link between the episode and the follow-up discussions
- Organisms with a spectacular or interesting morphology or ecology.

Hands-on activities both in and out of doors have to meet the criteria above to be useful in teaching (Dillon et al., 2006). It is important to see the episodic memories, which are something the majority of the class can share as an important starting point for a deeper discussion or theoretical reasoning. It is a starting point which can raise the motivation among students. We also know that these types of events can last for a long time and give rise to positive attitudes towards nature and fieldwork. It is important to help future science teachers plan hands-on activities in order to create memorable episodes.

**References**


**Physics through play**

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**Background, aims and framework**

Study activities called *Science games* were designed to teach pre-school children about certain physical phenomena and concepts in order to raise their awareness and increase their interest in those concepts (Arason & Norðdahl, 2005, 2006). The design of the activities is based on Vygotsky’s ideas on conceptual development and on knowledge about ideas older children commonly have about physical phenomena. The activities were designed with the idea that it is important in facilitating children’s learning to take into account how children think about the phenomena involved (Driver, 1983). Thus the design of the activities was based on research on children's ideas about relevant phenomena (Driver, Guesne & Tiberghien, 1985; Driver, Squires, Rushworth & Wood-Robinson, 1994).

Another important aspect is to give the children opportunities to discuss their ideas before, during and after engaging in the activities (Dewey, 2000; Vygotsky, 1978). This discussion gives the teachers valuable clues about children's thinking about phenomena which they can then act upon. The activities should give the children ample opportunities to handle things and to freely experiment with the objects involved and make their own observations. They should give many opportunities for the children to be active both physically and mentally. The children should play freely with the material, for example, by making shadows, and be able to alter the shadows by moving the light source so they grow bigger or smaller, and by moving the shadow around the object. In addition to these free activities, the teachers lead the children in subtle ways through predetermined activities such as using mirrors to change the direction of light and observing light going through holes in sheets of paper.
During the whole process the teacher has an important role in stimulating the children to enquire, focusing their attention on the important aspects of each phenomenon, laying a foundation to their conceptual understanding by introducing new concepts to the children, and encouraging the children to discuss their experiences. In these activities it is important that the teacher understands the possible learning outcomes and has the relevant pedagogical content knowledge in order to scaffold the children’s learning. The activities are designed to give opportunities for challenging common misconceptions about the phenomena involved (Driver et al., 1994). But these activities are also based on the idea that children learn best by playing with things and the teacher’s role is to enrich the play as a learning opportunity by guiding it in a mild way.

This study was intended to give information about how the activities affected the children. There were three research questions. Did the Science games:

- awaken children’s interests and give them enjoyment?
- focus children’s attention on the key factors in the physical phenomena involved?
- affect children’s understanding of the physical phenomena involved?

Within the field of science education limited numbers of studies have focused on young children (Fleer & Robbins, 2003), which is unfortunate as the educational experiences of young children are important for school success (Sprung, 1996; Novak, 2005).

Sample and methods

Eight teachers and about 80 children aged two to six participated in this study. Data were collected through observations and videotaping of small groups of children going through the activities with teachers. These sessions were followed immediately with informal interviews with the teachers. All the participating teachers collected data by keeping diaries about their experiences of working on the activities with children, the children’s responses to the activities, and comments made by parents. To gather more information regarding the influence of the tasks on the children at home, parents were asked to answer a questionnaire. In all, 50 sessions of the five different activities were documented over a period of five months and diaries were kept during that time. Some interesting follow-up data were collected for an additional year. The data were analyzed with regard to the categories relating to the research questions, those categories are children’s interest and enjoyment, their attention to the key factors in the physical phenomena involved, and any sign of understanding. The analysis was also open to any new category that would appear.

Results

One main finding of the study is that the children greatly enjoyed the tasks. The children were eager to use the material in diverse ways and they did their own experiments as well as the intended experiments. They also asked if they could play with the material at times when the tasks were not scheduled. An important and interesting result is that some children blossomed through participating in the project, which they did not necessarily do in other endeavours. Parents mentioned examples of children continuing the experiments at home.

The Science games helped to focus children’s attention and interest on key factors of the physical phenomena. Children often commented on key elements or responded to teachers’ questions about how they could make various things happen with the material. According to the teachers, children discussed and commented on the relevant phenomena between sessions. For example, at the lunch table they started experimenting with reflection in their spoons and remarked that their reflection was different depending on how they turned the spoon. Instances such as those continued for months following the completion of the project. Parents also mentioned similar examples of children’s enquiries and speculation at home. In general, we conclude that the tasks had an influence on how many of the children experience certain physical phenomena in their environment.

The weakest part of the study concerns the possible long-term effects of the project on children’s understanding of physical phenomena. The children’s ideas were not investigated or documented by interviewing, collecting drawings or other methods. However, some evidence of increased understanding of the physical phenomena was documented. One of the children said that a shadow was a lack of light. They learned to make shadows and affect the shadows by moving the light source so they grew bigger or smaller and they played with moving the shadow around the object. They seemed to understand that a coloured slide affected the light from the torch if it was placed in front of the torch. There were examples of children beginning to understand that light travels. For example, children mentioned things light could travel through, like plastic cans and a sweater, and one of the girls realized that light travels when the light from the torch was reflected from a mirror on to the wall or, as she put it, “it (the light) couldn’t go through the mirror”. Generally, we can say that the data give some indication of improvement of the understanding of some of the children.

Conclusions and implications

The main conclusion of this study is that physics activities designed as Science games can be successful in the early childhood education setting. The children enjoy such activities and become interested in physical phenomena. They want to participate time and again in the activities and also used the material in ways that they invented themselves. Activities of this kind can help to focus children’s attention on key factors of physical phenomena and have the potential...
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of improving children’s understanding. Teachers have an important role to play in focusing children’s attention on the key elements of the phenomena and in encouraging the children to experiment and discuss. Some important questions regarding the effect on children’s understanding of the subject remain largely unanswered, which shows a need for more research and development in the area of science education in pre-schools.

References


Video tales of teaching in Norwegian science classrooms

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Background, aims and framework

The aim of this paper is to describe and scrutinize teaching activities in a selection of Norwegian science classrooms, with a special emphasis on features of science and language use. This is done in order to shed light on and discuss the meaning-making activities students are offered in order to learn science. The present study is part of PISA+, which is a classroom video-study involving both mathematics and reading in addition to science in lower secondary school. It is a qualitative, in-depth study, which tries to scrutinize and understand the results from the past PISA (Programme for International Student Assessment) studies (Kjaernsli, Lie, Olsen, Roe & Turmo, 2004; Kjaernsli, Lie, Olsen & Roe, 2007; Lie, Kjaernsli, Roe, & Turmo 2001) and evaluation studies of Norwegian schools (Klette, 2003; Schmidt et al., 1996). PISA+ was established to pursue problematic PISA findings in the Norwegian context, and to illuminate the pedagogical processes that shape these findings. It is partly based on sociocultural principles from theorists such as Vygotsky (1934) and Bakhtin (in Holquist & Liapunov, 1982). Our goal is to offer some knowledge valuable for improving teaching and learning in schools.

However, by comparing videos from different classrooms and different schools we are also able to see to what extent these moments or classroom actions are typical of their kind. Different classroom actions are seen as part of a larger-scaled and longer-termed activity system of teaching science (Lemke, 2000).

Learning science

Learning is often portrayed as a meaning-making process. Mortimer and Scott (2003) describe learning as both individual meaning-making where old and new ideas are reconstructed, and dialogical meaning-making where ideas are shaped as they are expressed in language in a social context. Based on the Vygotskian perspective the use of language in a social context becomes of crucial importance for science education. Learning science is learning to talk science; learning to use structures and features of the scientific language (Lemke, 1990; Mortimer & Scott, 2003). Mortimer and Scott (2003) consider language as a fundamental tool for learning. They focus on the distinction between an everyday social language and a scientific social language based on Vygotsky’s everyday and scientific concepts (Vygotsky, 1934). They also focus on three fundamental features of the scientific social language: description (an account of a system, object or phenomenon), explanation (importing some form of a model or mechanism to account for a specific phenomenon) and generalization (a description or explanation that is independent of any specific context). Modes of communication are a natural part of this picture.

Lemke (1990) describes meaning-making as a process where words and artifacts are experienced in a context. Actions and occurrences become meaningful by being contextualized. He claims that you learn science by learning to use the
scientific language, not only by understanding scientific concepts, but also by how structures and thematic patterns for the science content are presented. Lemke reminds us that in all dialogue there are at least two different things going on; people interact with one another (the activity structure), and they also construct complex meanings about a particular topic (the thematic pattern). In our different levels of analysis in the PISA+ project, we are able to illuminate both organizational patterns and thematic patterns.

In our analysis we mainly draw on the works of Mortimer and Scott (2003) and Lemke (1990).

**Methods and samples**
The research design is a classroom video-study supported by ethnographic observations and interviews of students and teachers. An important research characteristic of this study is the documentation of sequences of lessons, rather than just single lessons. In addition the same classrooms are videotaped in maths and language art lessons. This makes it possible to compare sequences of lessons across disciplinary subjects such as language arts; maths and science. The study is done in ninth grade (students are 14-15 years old), in six schools differing in demography and organization. The classrooms are filmed with three cameras. One camera follows the teacher, one camera films the whole class, and one camera focuses on a pair of students. The teachers are interviewed before, during and after the observation period of three weeks. As a first step of analyses we have elaborated a coding scheme (Klette et al., 2005) for coding video-observations of teacher activities and instructional repertoires across sites and school subjects. The coding has been made in Videograph – a software tool which makes it possible to see frequencies and patterns of activities across classrooms, teachers and disciplines. The main categories concerning instructional format are whole class instruction; individual deskwork; and group work. In addition science specific analyses are done. The science lessons are coded using a scheme based on the works of Lemke (1990) and Mortimer and Scott (2003). We focus on teaching and learning activities in science and the use of everyday and scientific language, and whether the scientific focus is on descriptions, explanations or generalisations. An average of 35 science lessons are video-taped and analysed.

**Results**
The first level of analysis, which mainly concerns organisational patterns, is common for all three school subjects involved in PISA+. It indicates that in science education whole class instruction is the single most frequent activity (Klette et al., 2007). The two main activities connected to whole class instruction in science are dialogical instruction and task management.

The next level of analysis concerns only science lessons. We see that the activity structure offered by the teacher mostly involves developing new content. The two next most frequent activities are task management and practical work. However, surprisingly there is hardly any emphasis on summing up the lesson or student work. The students participate by listening, engaging orally or taking notes. Teachers use of task management is connected to either giving procedural instructions about practical work, or giving instructions about student assignments.

Although the teacher orchestrates most of the classroom dialogue, she or he is attentive to student initiatives, and quite a few times the movement of classroom talk is heavily influenced by student engagement. We observed that student initiatives are almost as frequent and influential as teacher initiatives.

However, in our material we hardly find situations where students focus on talking science with each other to elaborate their scientific understanding. Although we do have some hands-on science situations suitable for science talk, the conversation seems to focus on practical issues rather than substantial and conceptual topics. This observation is verified when we look at the scientific language coding. Like Mortimer and Scott (2003), we have studied which features of science are the focus of dialogues between teacher and students. This category is coded by following the teacher in all situations. In our material only a small part (less that 20%) of the overall dialogue has a focus on features of science. The most frequent feature is description. In-depth analyses of the language used in science lessons, show that scientific language, defined as the use of scientific concepts (Mortimer & Scott, 2003), occurs usually in only a small part of a whole lesson. However, we see that categorising the language as either “everyday” or “scientific” may be problematic.

**Conclusions and implications**
Our analyses of science classrooms reveal interesting information that may illuminate the past Norwegian PISA findings and give ideas for improvements in teaching science. The involved science teachers emerge as being very inclusive of student initiatives. They are responsible and loyal towards their school and students in meeting multiple requirements of organisation and adjustments. However, in this battle for attention substantial science issues seem to lose out.

Use of workplans and project work result in delayed feedback and seems to be the reason for the lack of summing up of lessons and student work. This in turn results in a quite periodic and varied learning demand. Workplans might also lead to individualised learning.
Finally, although fine-grained, in-depth analyses show us that teachers do not necessarily have to use scientific language in order to mediate general scientific patterns, other layers of analyses inform us that there is little overall emphasis on substantial scientific talk. It seems that the students are offered little exposure to the thematic patterns of talking science.

References

Investigating local school science cultures in order to facilitate long-term educational changes in science teaching
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Background, aims and framework
The term Local School Science Culture (LSSC) has been become a central concept in Danish science education policy papers (Andersen, Busch, Horst, Andersen, Daigaad, & Dragsted, 2006). This represents an increasing attention towards the complex social mechanisms involved in generating long-term educational change. Lack of qualified science teachers in Danish schools has become an issue of growing concern following teacher education reforms and the retirement of a large share of in-service science teachers. In order to achieve and maintain high levels of quality in science teaching it has repeatedly been noted by researchers that schools need to develop LSSC that can facilitate professional development and teacher collaboration (Dragsted, 2003). However, in order to improve the quality of science teaching in the long term we need to understand the underlying local factors that influence science teaching at the level of individual schools rather than individual teachers. Identifying these factors becomes pivotal to the success of any long-term effort to improve the quality of science teaching and to understanding why it seems to be so difficult to maintain educational changes over time (Hagreaves & Fink, 2006).

This paper describes a model for understanding LSSC that can be used to identify the complex local socially defined factors of individual schools that either work to maintain existing practices or that can become potentials for change and development.

Method and samples
The theoretical model for understanding LSSC presented here was developed through an empirical investigation of a large privately-funded three-year development project. The development project, called Science Team K, was launched in 2003 and aimed at improving science teaching and promoting children's (grade 7-13) interest in science (Busch, Sølberg & Horn, 2006; Sølberg, 2007a; Sølberg, 2007b).

From the very early phases of the project, researchers were allowed access to meetings and other activities of the development project. Surveys aimed at science teachers and students in the 14-16 age range were administered at the beginning and towards the end of the Science Team K project. In addition, school administrators from all 17 schools involved were interviewed after the project ended. Throughout the project period, ongoing contact with the people and activities involved with the development project was maintained to ensure an intimate knowledge of the progress.

Halfway through the development project, a qualitative case study was conducted to explore factors that hindered or facilitated development of LSSC. In this study, an early version of the model presented here was applied to analyse the LSSC of three selected schools. Each case school was selected based on an initial questionnaire involving 107
science teachers from 17 schools (Sølberg, 2004) and nine interviews with key people involved in the Science Team K project. In each of the selected schools three science teachers were observed by a researcher for one or two work days and subsequently interviewed based on the observational data. In addition, one or two school administrators were interviewed from each school. Following these initial phases of data collation and analyses, all selected teachers from each school were gathered for a group interview in order to validate and elaborate on the initial analyses of the LSSC. All qualitative data collected were analyzed using a grounded theory approach (Strauss & Corbin, 1998) and the qualitative analysis software Atlas.ti (see www.atlasti.de).

Results
The combined results of the empirical investigations lead to the formation of the following model for understanding LSSC. The model can be used to facilitate long-term educational development of science teaching by identifying hindrances and potentials found in individual schools.

LSSC are defined here as *the emerging result of the ongoing negotiation through participation in practice between key actors of relevance to science teaching in schools*. They are created, developed and maintained through the influence of a wide range of contributing factors that can be categorized into two closely interrelated categories:

- Key actors of the school
- The relationships between key actors

Key actors include a broad range of people (teachers, students, parents, administrators etc.) who individually contribute to the formation of shared qualities that can be categorized as part of the organisational culture. Through participation in practice, people who regularly interact with one another, become part of a continuing process of negotiation of meaning (Wenger, 1998). In self-organising systems, such as schools and other organisations, complex qualities can emerge from the ongoing interactions between contributing entities (Morrison, 2002). These qualities include shared basic assumptions, values and norms as well as artefacts that collectively constitute the organisational culture (Schein, 1992).

However, it is not only human actors that contribute to define the LSSC. The practical settings of the school are also considered to be important actors. This includes the geographic, economic and physical settings of the school, including availability and access to science labs, equipment, books etc. The practical settings are in and of themselves not active participants in the formation of LSSC, but the socially constructed perception of them influences the decisions of the human actors. As such, the practical settings are also considered to be key actors of the school (Law, 1992).

The second category of factors that influence LSSC is the relationship between the key actors. This category points to important issues that influence the degree to which key actors are able to play a part in the formation of LSSC. Such issues include issues of power, forms of communication, social hierarchies and organisational arrangements. Here, school leadership plays an important role in maintaining coherence in educational change initiatives and in providing the support to sustain the efforts of “engaged individuals” in the school (Wickenberg, 2004).

In 2003 Fullan remarked in an interview that as he looked back at the many development initiatives he had been privy to know: “The single factor common to successful change is that relationships improve” (Sparks, 2003). With this remark he points to one of the most critical issues of facilitating long term educational change: successful change does not come about by providing means and resources to do something different for a period of time – it requires careful attention directed towards changing the nature and basis of the relationships between the key actors involved.

Conclusions and implication:
Aknowledging the complexity of generating long-term educational change through the LSSC perspective described above has many implications for development initiatives aimed at improving science teaching at the level of individual schools. First of all, it emphasises the fact that no two schools are alike. Differences in local conditions such as managerial strategies and priorities, school goals, composition and size of student and teacher bodies, economic foundation and urbanisation of the area around the school, can pose significant barriers to or opportunities for educational change. Consequently, it is important not to assume that what works in one school readily transfers to others. At the level of individual schools, there may be significant hindrances for development embedded in the LSSC that need to be addressed before long-term educational change can occur. Without due consideration to the importance of local variations in individual schools, development initiatives aimed at improving science teaching across schools may end up benefiting the schools that are already thriving rather than the schools that need it the most.

Also, in order to avoid creating “individualistic teaching cultures” (Hargreaves & Fullan, 1992) by relying on individual teachers to head educational change alone, school leaders need to provide an overall vision for school science practices in accordance with other school priorities. In addition, it is critical for long-term results that teachers are provided with the necessary support structures to enable dedicated science teachers to become change agents. Support structures include, but are not limited to, providing ample opportunities for people to engage with each other in order to allow for
relationships to develop and cultures to emerge.

The model presented here is currently being applied to four separate small-scale development projects to facilitate long-term educational change and further details are to be found at http://lnk.wikispaces.com/.

References

Why can’t you see what I see? Development of expertise and enquiry based learning
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Background
Enquiry based learning is founded on the idea that knowledge is constructed in the mind of the student and that all that is needed is first hand experience with the world and its phenomena. The mythical scientific method describes a process from perception of phenomena to the generation of a hypothesis followed by a verification or refutation stage leading to understanding, and the making of new theories and models.

These descriptions rely heavily on the concept of a neutral, objective and universal ability to perceive the world. It also presupposes a rational, logical and foolproof cognitive system for analysis and inference.

But, we all know how sensory systems can be fooled and how difficult it is to observe the relevant data in a myriad of sensory input (Marois & Ivanoff, 2005; Walter & Dassonville, 2005). Analysis is very often “contaminated” with effect and feelings (Vuilleumier, 2005). People seldom behave rationally and logically (Nisbett & Wilson, 1977). Students often have strong preconceptions that refuse change or alteration. The ability to apply general knowledge and to transfer knowledge from one example to another seems to be very restricted.

Aims
This paper wants to show a new understanding of several of these phenomena in learning by using the latest findings from modern brain research:

• How does the implicit learning system affect our ability to observe, characterize and analyse phenomena in the world?
• How may this knowledge guide us in the design of enquiry based learning situations?
• How is the implicit system used in problem solving and “the scientific method”?
Method
This paper is an “integrative research review”, trying to find and show new aspects of experience-based learning and the development of problem solving expertise (Backman, 1998; Cooper, 1984; Light & Pillemer, 1984).

Framework
Modern research in psychology, supported with seminal findings in brain research, has given us a new model of the learning system that can explain much defiance and problems in the act of perceiving the world (Björklund, 2007).

A dual systems model of memory and learning was refined during the late 20th century and gives evidence for us to believe in two different ways of seeing, analysing and understanding the world (Squire, 2004; Zeithamova & Maddox, 2006). The Cartesian view of a split between the body and a separated single mind has moved towards a model where a conscious, explicit and declarative memory system lives alongside an unconscious, implicit and tacit system. The behaviour and function of this system has been studied by experimental psychologists and with this new information from brain imaging research a radically new understanding of knowledge and knowing is at hand.

The implicit system is evolutionary, very old, and has been studied for a long time in animals. Its function is to let the individual recognize situations where something important happened, some dangerous moments experienced or maybe an opportunity that led to a reward. Patterns of raw sensory data are “stored” in long term memories. Structures as the Basal Ganglias, the Amygdala and Striatum have been identified as areas active in this learning process (Cincotta & Seger, 2007; Ilg et al., 2007; Nomura et al, 2007; Seger, 2006).

Old philosophical aspects of knowledge known as “techne” and “phronesis” are given neurobiological causes and explanations. Intuition (Sinclair & Ashkanasy, 2005), gut feelings and tacit knowledge (Polanyi, 1967) could be understood and related to as individually learned experiences, i.e. knowledge stored in implicit memory.

Perception and evaluation
The visual system of man has for a long time been identified to certain areas in the back of the brain but questions have been asked how a slow, visual system looking in a narrow cone of view is able to identify and recognize objects in the visual field. New results from brain research have revealed another, evolutionary, much older system with its own signal routes which has a much wider field of view, is much faster and is able to match earlier patterns of sensory input encountered. This system seems to be directing the ordinary visual system to be able to focus, pay attention to (Castelhano & Henderson, 2005) and to identify objects and events (Duncan & Feldman Barrett, 2007; Epstein & Higgins, 2007; Kristjánsson et al., 2007; Laycock, Crewther, Fitzgerald & Crewther, 2007; Schunn et al., 1997; Volz & von Cramon, 2006).

By the use of different structures for positive or negative patterns, a somatic marker (Damasio, 1996), this system is able to not only detect and recognize complex patterns but also to evaluate them (Foley, Foley, Scheye & Bonacci, 2007). This system is used to initiate automatic neural responses, but also to give fast observation, evaluation and automatic action (Sun, Zhangb, Slusarz & Mathewsc, 2007).

Problem solving
Wallas (1949) proposed a four stage process of creative thought (Preparation, Incubation, Illumination and Verification) during which the thought process would move from conscious thought patterns, to unconscious and then back to conscious. Low (2006) describes these stages in his thesis:

- Preparation - This stage involves intense effort to solve the problem; the gathering of all data possible, problem identification and problem definition and if a solution is not found the problem is abandoned.
- Incubation - During this stage the problem solvers conscious thought processes are turned to matters other than the problem, while subconscious thought processes work on the solving of the problem. When a solution is arrived at the mind delivers the proposed solution from the subconscious to the conscious.
- Illumination - This is the “aha” or sudden insight into the possible cause or solution to a problem on which the researcher may have been working. In this model the subconscious mind “delivers” the solution or idea to the conscious mind.
- Verification - During this stage, the details of the solution found are checked against the reality and found to be either a valid solution to the problem or another way of not solving the task at hand.

In this four-stage model of creative thought, the dual systems model fits in with its explicit conscious memory versus the unconscious implicit memory. During the stage of preparation data absorbed about the problem is constantly matched towards stored implicit memory patterns. Since these are memories of specific instances (Nosofsky & Zaki, 2002) a very close likeness must be at hand for recognition to happen. A huge library of experiences/patterns and an elaborative exploration will facilitate the match (Reber, Ruch-Monachon & Perrig, 2007). This is what is promoted in the view of variation theory (Marton, 2006). In the case of an impasse this unconscious pattern matching may continue in the incubation stage, which has been demonstrated recently (Cronin, 2004; Dijksterhuis, 2006).
Conclusions and implications
The teacher or supervisor has by experience built a large implicit library of patterns and is therefore an expert in seeing what is relevant. This gives him or her an important role in guiding the novice in the exploration of a phenomenon.

- To be able to generate a good hypothesis one needs to explore the phenomena elaborately and one needs to have a vast experience of similar events, creativity comes from knowledge.
- Time for incubation may very well facilitate the process as several studies show (Cronin, 2004; Dijksterhuis & van Olden, 2006).
- The context must be friendly; one must be allowed to make mistakes and to take a risk when one generates a hypothesis. Otherwise the explicit system takes charge and one will not be able to use all implicit experienced data (Markman, Maddox & Worthy, 2006).

References
Squire, L. R. (2004). Memory systems of the brain: a brief history and current perspective. Neurobiology of Learning and
Gender theory as a tool for analysing science teaching

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Background

Research about gender issues within science education has had different focal points. One focus has been to recruit more women into natural sciences and technology, an endeavour which has required large investments. The assumption has been that if women only understood how exciting and interesting science is, they would freely choose these subjects. Another emphasis within science education research has been to clarify the differences in achievement, participation and interests between girls and boys (Johnston & Dunne 1996; Sjöberg, 2000). This type of research views girls and boys as relatively static groups and the conclusions have been that girls, for example, prefer a particular learning environment or are more interested in special topics within natural sciences. One way to take these preferences into consideration has been to change teaching in such a way that it also appeals to the “learning styles” of girls (Barton, 1998; Roychoudhury, Tippins & Nichols, 1995). Since girls are considered to “be” basically different from boys, female and male stereotypes are reconstructed and differences between the sexes are consequently observed, Johnston and Dunne (1996) argue. Instead the research should try to explain how gender is produced and reproduced in the scientific classroom. Therefore the focus of research ought to be on the science teacher’s teaching practice and her/his gender awareness.

In teacher education, cases have been used as a pedagogical element since the beginning of the 1990s to explain the complexity of teaching. Studies have shown that students who get the opportunity to discuss authentic classroom events reflect better on how teaching theories can be used in practice, and it is easier for them to analyze their own practice when they start to work (Lundberg, Levin & Harrington, 1999; Moje & Wade, 1997; Shulman, 1992; Sykes & Bird, 1992; Whitcomb, 2003).

We have used teaching situations transformed to cases in order to emphasize the participating teachers’ pre-conceived ideas about gender. The aim is to investigate to what extent teachers are aware of gender issues within the science classroom and to study if a change in their assumptions can be achieved.

The questions that guided the planning of the study are:

- How do science teachers analyse a case which describes a real classroom situation?
- In what way are teachers able to apply gender theory when reconsidering this case?

Method

The study was carried out during an in-service development Gender and Science course. Teachers active from pre-school to the later years in compulsory school attended the course. This study focuses on one specific task, a case, given to the participants. The case is based on a classroom event that took place in a school in Sweden in the beginning of 2007:

Sandra is an eleven-year-old pupil in the fifth grade. Her school is located in the middle of Sweden. The following event happens during a question and answer session about a science homework assignment. The homework consists of several new concepts. Sandra thinks that the concepts are a bit difficult so she had to work hard with the homework assignment the night before. During the science lesson, the pupils are given a written quiz. While they are working, the teacher walks around in the classroom observing the children.

“Sandra, you may step forward and write your answers on the whiteboard”, the teacher says after the pupils have completed the quiz. After Sandra has written down her answers, the teacher asks the pupils to raise their hands if they think Sandra has written the right answers. Some girls raise their hands, none of boys do.

“David, why do you think that Sandra has written wrong answers?” the teacher wonders.

“Because she is a girl”, David replies.

However, it turns out that Sandra has answered correctly and during the rest of the lesson, David sits with his head down.

The teachers worked individually with the task, wrote down their thoughts and reflections about the event and thereafter handed in their written responses. As a second task the teachers were given a text to take home, Hirdman’s theory of the gender system (Hirdman, 1990). This theory is based on the formation of a social pattern structured by the
gender order, and that this pattern can be seen in every society. It is characterized by two principles: the separation of the sexes and the superior status of the male standard. Hirdman’s theory is linguistically quite easy to comprehend, it is available in Swedish, it has had impact on the field of science in Sweden and influenced the political debate (Thurén, 2003). Informed by the theory, the teachers were requested to analyse the case again and to hand in their written reflections. Fourteen of the participating teachers completed these two exercises.

The teachers’ texts were analyzed in several steps. In step 1 the material from the first task was analyzed to find and form categories of relevance. In step 2 the texts from the second task were read to find sections that pointed out if the teachers had used references to gender theory and in what way they had used them. In step 3 a comparison was made on an individual level of the teachers’ explanations in the two different tasks.

**Results**

In the first task, a majority of the teachers explain that David, as well as most of the pupils, hold the idea that boys are better than girls, either in a general way or more specifically in science subjects. Why and how this has occurred is not touched upon by the teachers. In the second task when all teachers have read Hirdman’s theory, they can use her principles to explain the pupils’ actions. The male as the norm in the society becomes their explanation to why most of the pupils hold the opinion that boys are better than girls. The teachers use Hirdman’s theory but differ in their views to what extent individuals are involved in the constitution of the norm, from the opinion that the pupils and their teacher produce the norm themselves, to the opinion that the norm is something static that just exists and turns the pupils into victims.

Another explanation given by the teachers as to why David answers the way he does, that Sandra is wrong because she is a girl, is that he believes his answer is something all boys are willing to support. None of the teachers expressing this opinion attempt to explain why. After reading Hirdman’s theory, two of the teachers problematize the question about how the gender system is maintained by the way the boys see themselves as a group, backing up each other and uniting around one common opinion. Furthermore, these teachers think the boys have firmly grasped the notion of male superiority. However, they draw attention to the girls who resist the majority class opinion and who believe in Sandra. These girls have the courage to challenge the gender order.

The outcomes of this study are clear and suggest that if teachers have the opportunity to analyze a real classroom event after being introduced to a theoretical view of gender issues, they deepen their reasoning powers and evolve new interpretations. For example, five teachers couldn’t give any explanation to the pupils’ actions in the first task, but after reading Hirdman’s theory these five teachers all gave specific explanations of the situation.

**Conclusions and implications**

Several research studies point to the difficulties regarding attempts to change students’ as well as in-service teachers’ assumptions about social structures, family, classroom, society and the pre-understandings of conceptions within an academic subject (Kagan, 1992; Whitcomb, 2003). In the present study all teachers but one are able to apply gender theory to the case describing a real event. The fact that the teachers deepen and broaden their interpretations of a real classroom event when they are introduced to theory indicates that this method can be applied in teacher education. The use of cases can be a method to link theories to practical work. Gender theories are of particular relevance for the prospective teacher who has the responsibility of working towards the objectives of equality as stated in the Swedish curriculum. In a longer perspective this kind of task can affect the teachers’ own teaching by preparing them for similar classroom events and thereby increasing their ability to act and react more thoughtfully.

**References**


Drenge og piger i det danske tekniske gymnasium htx
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Baggrund, mål og ramme
Højere teknisk eksamen (htx) er en dansk treårig gymnasieuddannelse med særlig vægt på de tekniske og naturvidenskabelige (tek-nat) fag. Blandt de tre treårige gymnasieuddannelser er htx langt den mindste. 8% af en gymnasieårgang går på htx og 80% af eleverne er drenge i modsætning til de øvrige gymnasieuddannelser, som har et flertal af piger (Statistikbanken).


Køn og identitet er ikke givet, men konstrueres i et samspil med omgivelserne, hvor kønnen er ét blandt flere træk, som indgår i identitetskonstruktionen (Søndergaard, 1996; Davies & Harré, 1990). Pigers valg af uddannelse og deres deltagelse i uddannelsen handler således i høj grad om hvilke positioner, som er tilgængelige for pigerne (dvs. måder man kan være på og indgå i en given social sammenhæng som fx en uddannelse på), og hvordan de selv og andre reagerer på de positioner de indtager gennem deres valg.

Metoder og sample
Undersøgelsen bygger på kvantitative og kvalitative metoder. I dette paper inddrager vi:

• Internetbaseret spørgeskemaundersøgelse blandt alle 1. og 2.g elever på htx
• Observation af undervisning i to 1.g og 2.g-klasser på to skoler.
• Interview med 25 elever (18 drenge og 7 piger) fra klasserne.
• Interview med lærere tilknyttet klasserne – et gruppeinterview pr. klasse.


Resultater
Pigerne i undersøgelsen er glade for at gå på htx, og oplever ikke at klare sig dårligere end drengene. Der er heller ikke flere piger end drenge, som overvejer at afbryde uddannelsen. Drenge og piger nævner de samme forhold som svært ved at begynde på htx, nemlig især at det er en anden måde at lære på end folkeskolen, og det er svært at strukturer sin tid.

Langt flere drenge end piger synes imidlertid det er svært, at der er så mange flere drenge end piger (44% af drengene er helt enige eller enige, mens det gælder 15% af pigerne). 78% af drengene svarer da også ja til, at det ville være godt, hvis der var flere piger på htx. Heroverfor svarer 23% af pigerne ja, 23% svarer nej, og 54% svarer at de er ligeglade.
I et interview med en gruppe 2.g-drenge nævnes som et minus ved htx, at der ikke er piger. ”Det gør det hele blive sådan lidt mere drenget”, siger den ene, og en anden tilføjer: ”Sådan homoseksuelt”, og griner. Bag grinet ligger at de meget få piger begrænser drengenes muligheder for at vise deres seksualitet, og gør det vanskeligt at demonstrere den side af deres identitet. Men samtidig med at drengene synes pigerne er triste at se på med utjekket hår og tøj, så har udseendet betydning for, hvordan drengene opfatter pigernes kompetencer. Drengene svarer på et spørgsmål, at de ville grine, hvis der begyndte en pige med mærketøj og push-up-bh, fordi den type er lidt for popsmart. To interviewede piger har en tilsvarende opfattelse, og flere elever fortæller, at både pigerne og drengene neddæmper deres tøjstil. Kulturen kræver at pigerne nedtoner den måde de præsenterer sig på, fordi det kan få betydning for de øvrige elevers fortolkning af deres kompetencer (Hasse 2002). Der ligger en kobling af køn og kompetence i forhold til naturvidenskab. I spørgeskemaerne blev eleverne bedt om at erkære sig enige eller uenige i udsagnet ”Rigtige piger interesserer sig ikke for teknik- og naturvidenskab” (Figur 1). Over ¹⁄₃ af drengene og en femtedel af pigerne har en tilsvarende opfattelse, og flere elever fortæller, at både pigerne og drengene neddæmper deres tøjstil.

Figur 1  Intresser pige vs.dreng

For at opnå en legitim position på uddannelsen må pigerne distancere sig fra dominerende forestillingen om, hvad det vil sige at være pige. En del af pigerne giver det ingen problemer; de oplever htx som et frirum fra den dominerende pigekultur. Men modsætningen mellem at være ’rigtig pige’ og have interesse for teknik og naturvidenskab betyder at bestemte positioner ikke er umiddelbart tilgængelige for pigerne. De er nødt til at være piger på en måde, som ikke associerer til ’rigtige piger’. En stor del af pigerne deler denne skelnen mellem udseende og faglig kompetence, og begrænser dermed selv de tilgængelige positioner.


Selvom andelene varierer, er det de samme kendetegn, som scorer højest hos begge køn, og det går igjen i interviewene. Her ligger altså et grundlag for at fange både drenges og pigers interesser, men også en indikation på, at man kan komme til at overspille forskellene mellem kønnene, når det gælder interesser i forhold til naturvidenskab.

Der er en risiko for at kønsstereotyper påvirker pigernes egen måde at gå til htx-uddannelsen på, og de øvrige elevers og lærernes måde at læse pigernes deltagelse. Flere af de interviewede gav udtryk for at pigerne var mere disciplinerede, og arbejdede bedre i projekterne. Men lærerne oplevede også pigerne som 'kedelige' og drengene som mere 'udfordrende'. Når pigerne udfylder den opstillede elevrolle, læser lærerne dem som mindre interessante elever end de drenge, som ikke laver deres ting. Pigerne får dermed ikke anerkendelse for deres bidrag, og noget tyder på at pigernes interesser for det kreative og det eksperimenterende ikke er synlige for lærerne.

Konklusioner og implikationer

Undersøgelsen viser nogle tvetydigheder i spørgsmålet om drene og piger på htx. Analysen viser begrænsninger i hvilke positioner som er tilgængelige for piger på htx. Det hænger sammen med en kulturel forståelse som sætter et konventionelt pigebillede og faglig kompetence i modsætning til hinanden. Pigerne må derfor nedtone det kønnede i deres fremtræden for at anerkendes som legitime deltagere i uddannelsen.

For en del af pigerne er det en fordel af slipper ud af den konventionelle kønsopfattelse, men for at slippe helt ud af den, må de samtidig nedtone, at der kan være særlige problemer knyttet til det at være pige på htx. Pigerne kan derfor ikke tematisere særlige pigeproblemer (f.eks. at lærerne læser pigerne som ’kedelige’), fordi de dermed gir opmærksom på at de er – netop – piger! Pigerne er dermed fanget i en dobbelthed af frisættelse fra snærende konventioner, og begrænsninger i tilgængelige positioner og hvilke erfaringer de kan tematisere.

Samtidig er der en risiko for at gøre kønnets position på htx til et pigeproblem, og at overbetone forskellene mellem piger og drenge. Nogle af pigernes problemer handler om at være de færreste, snarere end at være piger. Nogle af begrænsningerne i positionerne gælder også for drengene (man må ikke være for smart). Og selv om piger og drenge interesserer sig for forskellige emner, er der store ligheder i de kendetegn de sætter højt i teknik og naturvidenskab.


References

Haptic influences on reasoning and learning in protein education
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Background, aims and framework
What is the colour of insulin? How does it find its target molecule and how does it experience its way to the specific binding site? Nobody has actually seen a molecule (directly without interpreting output from an instrument) so how to relate these questions to one’s experiences? The importance of representations in molecular sciences is obvious and the impact of visualization in molecular life science can hardly be overestimated. Indeed, today the ability to interpret visualizations is a prerequisite for understanding molecular life science. However, choices have to be made with respect to how the molecules are to be rendered visible, and simplifications are inevitable since all features and properties cannot be detected and shown simultaneously.

Starting in the early 1960s, biomolecular visualization has changed from using physical models to increasingly advanced computer graphics tools (Francoeur, 2002; Tate, 2003). The developments are in fact transforming the way we describe and think about the events and processes in molecular life science, and visualization tools are important for analysis of bio molecular structure, and to better understand molecular interactions. But they also provide new ways of teaching, which are expected to aid the understanding of the molecules’ structures and their interactions. In several cases these tools have proven to be powerful cognitive aids but there are a number of considerations to be made and scientific knowledge about the learning process is still sparse.

Kozma and his co-workers conclude that the way we understand chemical phenomena is connected to the use of external representations (Kozma, 2003; Kozma, Chin, Russel & Marx, 2000; Kozma & Russell, 2005). The impact of computer-generated representations on learning has so far mostly concerned visual representations.

Haptic technology refers to technology which interfaces the user via the sense of touch by applying forces, vibrations and/or motions to the user. While visuals can convey information in a more rapid and encompassing way, helping in the perception of larger (macro) structures, haptics is often superior when investigating smaller (micro) geometric properties (Lederman, 1983; Zangaladze, Epstein, Grafton & Sathian, 1999). In some contexts, the combination of the two senses can be superior to either alone, and the ability to use kinaesthetics may help in grasping concepts concerning physical phenomena (Insko, Meehan, Whitton & Brooks, 2001).

In the research that has been carried out to investigate the area of using haptics in educational settings, the use of force
feedback appears to ease the understanding of a variety of complex processes. In particular gains are shown when dealing with cases that include elements of forces we handle regularly (such as in mechanics) or when there exists an intuitive translation from the studied phenomenon into force, for example. In the work of Reiner (1999) it was shown that after using a simple tactile interface to a computer program, students developed a concept of fields and constructed representations close to those of formal physics.

Haptics can enable a user to feel intermolecular forces or even subatomic structures, such as the electron density function, through a force representation. Using haptics and force feedback, physical interaction can be reintroduced, but this time the interaction is with computer models rather than physical models. In contrast to the original physical models, force feedback allows the model to mediate intermolecular forces, attractive as well as repulsive, experienced by ligands. This technique is used in the Chemical Force Feedback (CFF) system, developed by us.

The overall aim of the study is to investigate if the haptic modality of the computer model can promote a deeper understanding of the factors and processes involved in the process of docking a small molecule to a protein. This is a process where students have considerable difficulties connecting their knowledge to a coherent whole. More specifically, we ask:

Does haptics affect what students learn and how they learn?

**Methods, sample and research design**

The subjects in the investigation were students taking the course “Biomolecular interactions” which is part of the master’s program in chemical biology at Linköping University. This course focuses on bio molecular structures and interactions, in particular interactions between proteins and ligands, and also gives a thermodynamic background to factors determining structure recognition (how, for example, a drug molecule recognizes and binds to its target protein). The goal is to give the students an understanding of the dynamics of molecular exchange. In order to achieve this level of understanding they have to get a deep understanding of concepts and processes determining molecular docking and to recognize the chemical and sterical constrains, the dynamics of molecular systems, the stochastic character of the process, exchange processes, intermolecular dynamics between protein and ligand and intra molecular dynamics in the protein, and the relations between affinity and kinetics and their correlation to binding energy.

Twenty students (8 women and 12 men) participated in the study. The students were divided into two groups using an initial domain test. The aim was to get an even gender and achievement level distribution between the groups. Both aims were attained with an average score on the initial domain test of 44 and 48 for the test and reference groups, respectively, and a gender distribution of 6 men and 4 women in both the test and reference groups.

The studies were focused around a computer laboratory using the CFF-system as a thinking tool to investigate the docking between a protein (carbonic anhydrase) and a set of ligands. The aim was to find the best docking for each ligand, each ligand producing a different affinity to the enzyme.

The tool was used with different conditions for the force feedback element. One group of students, the test group (H) performed the task with force feedback enabled, whereas the other group (NH) had force feedback disabled. Performing the computer lab was a compulsory element in the course, while participating in the research was voluntary.

The study followed a classic test-reference group design. Data were collected before and after (surveys, pre- and post-tests, and interviews) and during (task responses and dock files) the computer lab. The pre-and post-tests were given in immediate connection to the tasks. These tests were designed to enable an estimate of the potential cognitive gain from the use of the haptic representation; estimated after applying statistical analysis. The performance (answers to questions) on the tasks was graded and the docking performance assessed from saved results from the students’ dockings (dock files).

The pre- and post-tests also included open ended questions and these, together with the students’ written answers to the tasks, were analyzed for scientific content, depth of understanding and a linguistic analysis of type of reasoning (see below).

**Results and conclusions**

A significant effect on learning (learning gain) was observed after the computer-lab session for both the H- and the NH-group (F(1,18) = 4.76, MSE = 9.01, p<0.05) (Figure 1). However, a strong trend indicated that the students using the haptic device (H) learned more (F(1,18) =3.773, MSE = 15.93, p<0.07).
Not unexpectedly, the students who knew more about the process of ligand docking at the pre-test docked their ligand more successfully.

The main findings, however, are to be seen in the qualitative analysis of the written responses on worksheets and the open questions in pre- and post-tests.

When analyzing the students’ verbal resources while reasoning, five categories (semantic fields) emerged, here referred to as steric-, chemical-, force-, dynamic and energy (Table 1). The reasoning in the pre-test responses is dominated by chemical and steric reasoning while the use of force and energy expressions is rare. In the post-test there is no major change in the reasoning pattern compared to the pre-test for the students who have used the tool without force-feedback (NH-group). The use of steric reasoning appears to be more independent of the force-feedback experience. However, the students who have experienced the force-feedback (H) appear to use expressions from the force category much more frequently and decrease their use of expressions in the chemistry category in their reasoning. The number of words in the energy category is relatively small, which makes interpretation difficult. The corresponding analysis of the use of words and expressions in the task responses revealed a similar pattern (data not shown).

Table 1 The distribution of words (in %) between five different semantic fields (chemical, steric, dynamics, forces and energy).

<table>
<thead>
<tr>
<th>Test</th>
<th>Condition</th>
<th>Chem</th>
<th>Steric</th>
<th>Dynamics</th>
<th>Forces</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>NH</td>
<td>48</td>
<td>26</td>
<td>11</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Post</td>
<td>H</td>
<td>21</td>
<td>21</td>
<td>17</td>
<td>35</td>
<td>6</td>
</tr>
</tbody>
</table>

Analysis of the students’ comments in their written questionnaires revealed two major points:

- The tool with force-feedback was valued higher than the one without by almost all students. Giving the students feedback helped them to find the docking position and guided their reasoning.
- A frustration due to challenged preconceptions. Several of the students complained over the bumping and shaking of the ligand when they tried to dock it, and some wanted to be guided to the correct docking position and were disappointed that they had to use chemical knowledge and combine it with the tactile experience.

In summary, the computer model appears to help the students to gain a deeper understanding of the docking process, partly by challenging their preconceptions. Further, we propose that the force feedback might constitute a critical feature for understanding the involvement of the dynamics and the forces involved in the process.

References
Studiemønstre på naturvidenskabelige grundfag

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Introduktion

Studerendes frafald og fastholdelse er komplekst forhold. Vores hypotese i dette studium er at spørgsmålet om frafald og fastholdelse vedrører relationen mellem den studerende og studiet bredt forstået, og denne relation afhænger både af studiets konkrete struktur, opbygning, faglige indhold, undervisningsformer, studiemiljø etc. – og den studerendes egne præferencer, tidligere erfaringer og oplevelse af studiet. Med udgangspunkt i et kvalitativt etnologisk studie ved det humanistiske fakultet, Københavns Universitet (Damsholt et al., 2003), om studerendes relation til deres studium beskrevet som et antal studiemønstre, sigter dette studium på at udvide undersøgelse til også at omfatte naturvidenskabelige grunduddannelser og professionsuddannelser, samt at udvikle et kvantitativt instrument i form af et spørgeskema der kan ”måle” studerendes studiemønster med henblik på at danne grundlag for udvikling af uddannelserne. Artiklen beskriver det metodiske arbejde med at udvide undersøgelsen og at omsætte de kvalitative data til et spørgeskema samt resultatet af pilotundersøgelsen.

Baggrund, formål og videnskabelig ramme

Ud fra en lang række undersøgelser, herunder kvalitative interviews med 173 informanter, analyser og spørgsmål, nåede Damsholt et al. (2003) frem til fem kvalitativt forskellige måder at opfatte det gode studieliv på:

- Det udviklingsorienterede studiemønster, kendtegnet ved et fokus på personlig faglig udvikling, faglig fordybelse og engagement
- Det lystorienterede studiemønster, kendtegnet ved et fokus på først og fremmest at dyrke sine interesser; studiet har lidt fritidspræg
- Det joborienterede studiemønster a (det professionsorienterede studiemønster), kendtegnet ved et fokus på studiet som et middel til at kvalificere sig til en bestemt profession eller et job af en særlig karakter
- Det joborienterede studiemønster b (det arbejdsorienterede studiemønster) kendtegnet ved et fokus på studiet som en adgangsbillet til et godt arbejdsmarked
- Socialt orienterede studiemønstre, kendtegnet ved et fokus på de sociale sider af studiet
- Det engagementssøgende studiemønster, kendtegnet ved en søgen efter at finde et studiemæssigt engagement hvor det karakteristiske er at det ikke er fundet endnu.

Nedenfor er beskrevet hvorledes disse studiemønstre er blevet udvidet til at omfatte de naturvidenskabelige grundfag og professionsuddannelser indenfor sundhed, teknik og naturvidenskab og derefter viderebearbejdet til et spørgeskema med en række udsagn der skal besvares efter en Likertskala.


Arbejdet med studiemønstrene lægger sig op ad den fænomenografiske tradition ved at have en relationel tilgang til studiet af forholdet mellem den studerende og studiet, men adskiller sig fra de hidtidige fænomenografiske studier ved at studiet og uddannelsen betragtes i et mere overordnet eller udvidet perspektiv, nemlig i det etnologiske perspektiv af den studerendes hele studieliv; ikke den studerendes tilgang til undervisningen i snæver læringsmæssig forstand. Man kan således sige at studiemønstertilgangen komplementerer den fænomenografiske tilgang og der åbnes således mulighed for at korrelerer resultater fra studiemønsterundersøgelser med fænomenografiske undersøgelser.

Et andet lighedstræk mellem den fænomenografiske tilgang og arbejdet med studiemønstrene er at de empirisk fremkomne kategorier betragtes som kvalitative forskellige måder at forhold sig til studiet på, snarere end en kategorisering af grupper af studerende. Den enkelte studerende kan således godt have træk fra mere end et studiemønster.
Metode og data


- Det kompetenceorienterede studiemønster, der er kendetegnet ved et fokus på at mestre faget og udvikle sine personlige og faglige kompetencer gennem studiet.

Det blev derudover besluttet at betragte det socialt orienterede studiemønster som en baggrundsvariabel, altså en individuel orientering hos den enkelte studerende uafhængig af valgt uddannelse.

Udviklingen af spørgeskemaet ud fra de 6 studiemønstre foregik i tre iterative processer. I den første proces var målet at forfinde forståelsen og beskrivelsen af de enkelte studiemønstre og fremdrage deres særkender i forhold til hinanden ved at diskutere hvordan en forestillet ideel repræsentant for det enkelte studiemønster ville forholde sig til en række temaer, som for eksempel 'den gode underviser', valgfrihed i studiet, praktikophold, eksamen, forholdet mellem studie og fritid etc. Resultatet af denne proces var udfyldt matrix med temaer i den ene dimension og studiemønstre i den anden.

I den anden proces blev denne matricens beskrivelse af hvert studiemønster omsat i et narrativ der beskrev en ideel studerende indenfor hvert studiemønster. I den tredje proces blev temaerne i matricen endeligt inddelt, så at der blev omdannet de overordnede temaer til et par mere grundige temaer. Resultatet af denne proces var en række udsagn, et for hvert studiemønster under hvert tema, samt ti spørgsmål om det socialt orienterede studiemønster samt generel tilfredshed med studiet. Da skemaet blev behandlet med Rasch scores er de i alt 64 spørgsmål i spørgeskemaet opdelt tematisk.

I pilotundersøgelsen blev spørgeskemaet besvaret af 236 studerende fra Historie (KU), Etnologi (KU), By og Byg (DTU), Design og Innovation (DTU), Medicin (KU), Matematik (KU), Kemi (KU), Nanoscience (KU) og Fysik (KU). I kraft af den første studielivsundersøgelse havde vi et ret klart billede af de dominerende studiemønstre indenfor Historie og Etnologi og disse studier kunne således fungere som en slags kontrolgruppe.

Resultater


Der blev fjernet 6 items og den grundlæggende skala ’helt enig’, ’delvis enig’ - - ’helt uenig’ blev dikotomiseret til ’enig’ vs. ’ikke-enig’. Derefter blev Raschanalyserne kort på omdefinerede skalaer og, bortset fra en enkelt tilføjelse til justeringer, passede de observerede data til Raschmodellens krav. De seks studiemønstre kan betragtes som betingede uafhængige og kan danne grundlag for tegning af ’profiler’.

Den statistiske analyse viste således at spørgeskemaet er kvantitativt valideret. Den kvalitative validering gennem interviews om opfattelse af de konkrete spørgsmål med 10 respondenter fra forskellige fag, tegner imidlertid et mere komplekst billede. Der er enkelte spørgsmål der giver anledning til tvivl om fortolkningen hos respondenterne.

Fordelingen af studiemønstre på fag indeholder flere interessante elementer (Figu 1).
For det første ses det at fordelingen på de to humanistiske fag der udgør kontrolgruppen, etnologi og historie, har en forventet fordeling af studerende på studiemønstre idet en rimelig gruppe studerende er udviklingsorienterede, mens en større gruppe etnologistuderende er kompetenceorienterede (metodisk orienterede) og arbejdsorienterede (der er ingen arbejdsløshed indenfor faget).

Professionsuddannelserne, By og Byg, Medicin samt Design og Innovation fordeler sig ligeledes forventeligt på det kompetenceorienterede og det professions- og arbejdsorienterede. Vi er heller ikke overraskede over resultatet for Nanoscience.

Den for arbejdsgruppen store overraskelse er de naturvidenskabelige grundfag, fysik, matematik og kemi. På disse studier er flertallet af de studerende neutrale eller negative over for alle de foreslåede studiemønstre. Vi havde forventet en fordeling af studerende her meget lig den for etnologi.

**Implicationer**

I forlængelse af den kvantitative og den kvalitative vurdering arbejdes der p.t. på et revideret spørgeskema med et tema mindre der forventes pilottestet i løbet af foråret. Det overvejes at indføre en afkrydsningsmulighed med ”udsagnet giver ikke mening” eller lignende, således at vi kan få mere præcis information om de studerende på de naturvidenskabelige grundfags reaktion på spørgeskemaet.


Allerede det reviderede spørgeskema vil kunne danne grundlag for longitudinal studier med henblik på at undersøge tiltrækning og frastødning samt ændringer studiemønstre indenfor de enkelte studier. Med dette instrument i hånden vil vi således have et grundlag for at designe mere rummelige studier der retter mod sig en bredere gruppe af studerende.

**References**


Implementation of empirical-mathematical modelling in upper secondary physics: teacher interpretations and considerations

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Background, aims and framework

Models and modelling receive increasing attention from the science education community as important components of contemporary science education (Gilbert, 2004; Gilbert & Boulter, 2000; GIREP, 2006; Greca & Moreira, 2002; Hestenes, 1987). In this paper, we draw on experiences from a project, PHYS 21, which has implemented an empirical-mathematical modelling approach in upper secondary physics education in Norway (Angell, Henriksen & Kind, 2007). By empirical-mathematical modelling we mean physics teaching emphasizing activities where students conduct experiments and construct and evaluate mathematical models of phenomena. We see modelling as important both because it reflects the nature of physics and because modelling activities are considered useful for learning physics concepts and processes.

Dolin (2002) suggests that physics appears difficult because it requires students to cope with a range of different representations of physical phenomena (experiments, graphs, verbal descriptions, formulae, pictures/diagrams) and to manage the translations between these. According to Prain and Waldrip (2006), a focus on multiple representations may contribute to effective science learning by catering for students’ individual learning needs and preferences and promoting students’ active engagement with ideas and evidence. Thus, the use of different representations was emphasised in PHYS 21.

In this paper, we look at how the curriculum approach was received and implemented by project teachers in the classrooms, more specifically:

- How was the intended empirical-mathematical modelling curriculum (PHYS 21) interpreted and adapted by project teachers?
- How did the PHYS 21 philosophy fit into the existing ‘culture’ of physics teaching?

Methods and samples

PHYS 21 took place over a period of three years: An introductory year with teacher workshops and design of learning activities; a ‘pilot year’ and a full implementation year (2005–2006). Ten schools and about 20 physics teachers participated in the initial phases of the project, whereas six schools, 13 teachers and 289 students took part during the full implementation year, employing the PHYS 21 course material and activities involving empirical-mathematical modelling along with a focus on multiple representations and scientific reasoning.

Three workshops and several regional meetings for project teachers were arranged. A teacher booklet introduced the view of physics applied in the project, aspects of scientific method and reasoning, examples of scientific models and the modelling process, and suggestions for student modelling activities.

Researchers visited all project schools during modelling activities. After the full implementation year, a short, online questionnaire was administered to the 13 teachers who had been actively involved in teaching PHYS 21. 12 teachers responded. The questionnaire comprised both open questions and closed questions with a 4-point Likert scale.

Semi-structured interviews with six teachers were conducted during the pilot year. Interviews were transcribed and analysed qualitatively with special attention to teachers’ interpretation of the project’s purpose, their descriptions of actual implementation in the classroom, and their views on physics and on teaching and learning. Interpretations were
discussed among the researchers, and the transcripts were reread to check preliminary interpretations until a consistent account was constructed and agreed upon.

**Results**

Indications of the degree of teachers’ dedication to the project may be extracted from the questionnaire. Responses showed that the majority of teachers had conducted the ‘obligatory’ modelling activities in their classrooms. When asked to indicate the percentage of classroom time where the ‘modelling idea’ was prominent in their teaching, eight teachers gave answers in the range 15%-30% and four teachers answered less than 15%. Most of the teachers answered ‘to some extent’ when asked to what extent they felt that PHYS 21 had changed their teaching practice. The teachers were also asked to what extent they thought PHYS 21 had improved students’ understanding of physics, of the nature of science and of the role of experiments in physics. The majority responded ‘to some extent’. On the question of whether PHYS 21 had increased students’ motivation and interest, answers varied more.

Most teachers had applied the modelling approach when teaching mechanics, but they found it difficult to continue in ‘modelling mode’ in their teaching of other topics. However, all the teachers expressed that they would continue to employ the material and the philosophy from PHYS 21 in their future teaching.

All six teacher interviews indicate that new curriculum ideas were adapted to teachers’ ways of doing and reflecting on teaching and learning rather than radically changing these. They all found a place for modelling in their personal rationale for teaching physics. Similarly, Stein, Smith and Silver (1999) claimed that teachers interpret new ideas and practices through the lens of their existing habits of practice and filter information about new ways of teaching through their prior experiences.

Physics teaching is generally known to be ‘conservative’ (Angell, Henriksen & Kind, 2004). Carlone (2003) describes how ‘prototypical physics’ is maintained and reproduced even in an allegedly ‘reformed’ physics course. All the teachers in the PHYS 21 project referred to ‘traditional teaching’, and some expressed that a motivation for being involved in PHYS 21 was to break out of this pattern. However, what the teachers saw as a main problem of physics teaching was the way it is delivered, not the content of the subject. Classroom observations and teacher interviews show clearly that “modelling as a method to teach physics content” was found to be most attractive by the teachers. Although several of the activities were designed to teach ‘modelling’ rather than concepts, the teachers assessed their quality in the perspective of conceptual learning. Teachers generally agreed that learning skills and learning ‘about physics’ were important, but they had few strategies for handling these features in their teaching.

Physics teaching is embedded in a more general ‘school culture’ where the attitudes of students, parents and society at large are involved. Some PHYS 21 teachers reported difficulties in getting students to adopt the way of thinking and working with physics employed in the project. It has been documented before (Angell, Guttersrud, Henriksen & Isnes, 2004) that students have certain expectations concerning ‘proper physics teaching’. These expectations are often influenced both by school culture (Carlone, 2003), and by parents and peers (Geelan, 1997).

In promoting modelling in physics teaching, it appears important to focus not only on teaching materials, but also on the views on the nature of science and on physics learning that underlie teachers’ practice. Many project teachers had not ‘internalised’ the view of physics as models that was underlying the project. Similarly, Henze, van Driel and Veerloop (2007) typify three characteristic ways in which teachers conceptualise and use modelling in science teaching, and they identify a need to extend teachers’ knowledge about the use of models and modelling in teaching scientific inquiry and the nature of science.

**Conclusion and implications**

In this paper we have pointed out some challenges connected with implementing modelling in an upper secondary school physics course. We do think that there is reason to develop this strategy further. It takes long-term work, both with teachers and with students, to adopt and internalize new views on the nature of physics and what it means to teach and learn it, but the rewards may be rich in the form of competent, motivated and reflective students taking their skills and understanding with them out of the physics classroom and into the workforce and civic life.

**References**


Pedagogical practices


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**“What matters is communication”. Secondary students’ responses towards a science learning environment**

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**Background, aims and framework**

This presentation focuses on the response of students to new types of learning environments. It draws on two studies carried out by the author. The first study is practitioner research (McNiff, 2002) on the response of students at the Suðurland College (Fjölbrautaskóli Suðurlands) to a new type of learning environment. The college is located in southern Iceland and the number of students was 850. The presentation also draws on results from the *Intentions and Reality (IR)* project which is funded by the Research Fund of Iceland and co-funded by the Iceland University of Education. The project was designed to examine developments in science and technology education in Iceland. The following research question was put forward: What is the nature of the gap between the intended curriculum and the actual curriculum – the intentions and the reality? One of the subsidiary questions was: What influences student choice with regard to science and technology in secondary, further and/or higher education? As part of the project, the researcher took part in three group interviews with students in upper secondary schools. The interviews took place in autumn 2006 and spring 2007.

In 1999 a new national curriculum for upper secondary schools was published (Menntamálaráðuneytitið, 1999). It contained three new course descriptions for natural science, in geology, biology and physics/chemistry. These courses where obligatory for all matriculation examination students. They were meant to enhance understanding and connection to everyday life (Pétursdóttir & Macdonald, 2007). It was intended that students of different ability and interest take the courses regardless of which study programme (language, natural science, sociology) they were pursuing; the courses would be foundation courses in natural science.

In the case of the practitioner research being reported here, the college decided to make a pilot project merging two courses into one (geology + physics/chemistry) with lessons from 9:00-12:00 four days a week. Features of the new environment included an emphasis on lectures in relatively big student groups (50 to 70 students), group work, assignments, information technology and field work. It was expected that one teacher would be assigned to the course for every 25 students. The teaching team, which participated in the pilot project, consisted of two to three teachers; the researcher was the course coordinator and also taught parts of the course.

The course was divided into five sections. The first section was a two week introduction, but the other four lasted three weeks each. Every section had its own theme, like groundwater, mapping and weather, geothermal, earth material and energy resources. The last four sections finished with an examination (often digital) and a student evaluation (digital). The new environment was based on the impact of using cooperative learning strategies (Chang & Mao, 1999; Johnson, Johnson & Holubec, 1994) and inquiry-based learning (Exline, 2004). Through the new environment the teachers hoped to encourage positive attitudes towards science (Osborne, 2003; Simon, 2000). At that time, the Suðurland College had decided to emphasize IT and to make computer supported learning a fundamental factor in the course (van Weert & Pilot, 2003).

The purpose of the research was to find out what the students thought about the new course. Based on the results there was an opportunity for the school to decide whether to continue the pilot project (the course), and whether to emphasize the teaching methods, the learning environment and/or information technology.
Methods and samples
The practitioner research emphasized the student view. The key question of the research is: What are the responses of secondary students towards the non-traditional science learning environment that characterizes the course? The leading questions were: How do the students like the learning environment? How do they like the cooperative learning method? How do they like the problem-based learning method? How do they like using computers in school?

Data were collected on student answers to a questionnaire about the use of information technology, group work, attitudes toward science, and learning and teaching methods. In all 185 students responded to the questionnaire. These contained both multiple choice and open-ended questions and were collected four times throughout the course in three terms during the years 2003-2004. Furthermore, semi-structured interviews with six students about group work were carried out in spring 2003. The students also made a daily report about the group work.

The mean age of the students was 18 years. In the autumn terms 2003 and 2004 about 60% of the students were 16 years old and 66% of the students were enrolled in the study programme for matriculation in natural science. In the spring term 2004 only 16% of the students were 16 years old and 39% were between the age of 19 and 25. In that term only 28% of the students were enrolled in the study programme for matriculation in natural science. Most of the students, 46%, were enrolled in the social sciences programme.

The interviews were in a college of 450 students located in east Iceland, in a college of nearly 700 students in the urban south-west, and in Reykjavík in a college of 2000 students. There were three group interviews with four to six students, and one individual interview. Altogether 14 students were interviewed, with a mean age of around 19 years. They were in the second half of their studies, more often enrolled in the study programme for matriculation in natural science but also the social sciences programme. The interviews were organized with 12 questions which were meant to answer three key questions: What kind of teaching and learning styles are found among teachers and students in science teaching? What is the attitude of Icelandic students towards natural science? What kind of elements influence students towards natural science?

Results
The results of the practitioner research show that student attitudes to lectures vary and seem to depend on their basic knowledge of the content of the lecture. The less their basic knowledge the more difficult it was for them to make use of the lecture. The size of the group seemed to have a disturbing impact on the students in the beginning but they seemed to acclimatize to this feature with time.

Those students who had their own laptop computer said that their computer competence had improved during the course but many of them put forward the view that the computer disturbed their concentration on other learning tasks.

Although most students mention group work as the most positive part of the learning environment their views on its usefulness vary considerably. Those most critical towards it are in general able students who complain that they are required to do most of the job given to the group and feel that it is not fair that all group members get the same grade for the group’s task. However, most of the students think that the main reason for unequal distribution of workload is due to laziness on their part and their lack of interest in the subject. Other explanations were offered, for example, that some students simply want others to do the job for them, that some students are pushy and prone to take control so that others in the group have difficulties becoming active participants and that some students are simply too shy or reserved to make a contribution. Some of the students interviewed pointed to a lack of security, trust and power status as the main factors underlying failed group work. But if the relations between group members were positive this kind of learning method was definitely the most popular. Quoting a student: “It is the communication that changes all.”

An effort was made to evaluate the quality of the cooperation presented in various study groups (Johnson, Johnson & Holubec, 1994). The interviews showed that students in the same study group experienced the cooperation so differently that evaluation of the group itself seemed improper.

In the interviews the students were not very keen on group work. They mentioned the importance of experiments and laboratory work and of relating the topic to the daily world. In one of the interviews the importance of fairness in the communication between teachers and students was discussed and it was pointed out that students with low self-esteem in natural science tend to experience guidance from teachers as degrading.

Conclusions and implications
This science course, lasted for seven years, 2000-2007. During these years the teaching methods and the learning environment were partly used in other courses, especially by the pilot project teachers. The Suðurland College still emphasizes IT.
The conclusions of the research are teacher-oriented, based on the students' views. They are surely superficial but they remind teachers that although some teaching methods are more favourable than others, education is an individual process and different instructional strategies suit different kinds of personalities. Furthermore group work/cooperative learning as a teaching strategy should be carried out with care as students' attitude on its usefulness vary considerably. That refers to execution and assessment of the group work. Furthermore communication between teachers and students with low self-esteem in natural science should be characterized by encouragement, and an avoidance of judgment and dissuasion.

References

Digital support for inquiry, collaboration, and reflection on socio-scientific debates
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Background, aims and framework
There is increasingly more pronounced evidence of a decline in the interest of young people to study science and retain the option of pursuing science related careers. In the past decade, there has been mounting evidence that the problem has become more acute. Studies, such as those performed under the ROSE project (Sjöberg & Schreiner, 2006), have indicated that most youth surveyed expressed positive attitudes on the importance of scientific and technological issues to society. However, the students show a diminishing interest. The change in attitudes appears to be more severe in developed countries.

We believe that one of the reasons that students, especially during the critical period of 11-14 years old, lose interest in science is the lack of appropriate curriculum materials that help them connect the scientific enterprise to human activity, and, specifically, the role of the accumulated scientifically-based knowledge and technological development in their everyday life. Hence, one strategy to make science more appealing and promising for meaningful learning is to integrate new technologies in the teaching. In this project we develop interactive web-based inquiry materials that embrace the guided constructivist approach to learning and support collaborative and reflective work. We engage small groups of teachers in the design and implementation of these environments so that a mechanism can be developed with potential for subsequent scale-up.

Students need help in order to manage the complexity of data-driven inquiries. The need for reflective inquiry scaffolding, especially when students are engaged in complex investigations, has been extensively discussed in previous research (Davis, 1998; White & Frederiksen, 1998). Without appropriate scaffolding, it is reported that it might be difficult for many students to engage in high-level reasoning when dealing with data-rich environments. Reflective practices, such as ongoing monitoring and evaluating one's processes and products, are especially important in inquiry-based science, where students are asked to take an inquisitive role towards learning and assume responsibility of regulating their problem-solving activities. Students are reported to face several challenges when engaging in open-ended, data-rich, inquiry investigations that relate to such issues as managing large data sets, keeping descriptions and interpretations of the data distinct, interpreting data as they relate to hypotheses, and construct evidence-based explanations (Sandolav, 2003; Schauble et al., 1991). In order to solve these problems students need to coordinate their cognitive and metacognitive strategies (Reiser, 2004) and engage in reflective inquiry. Traditionally, reflection is
something reserved for the end of the learning sequence (Loh, 2003); this can be problematic in that a reflective stance to learning is necessary throughout the learning process in student-led environments. The web-based learning environment in this project will be used in collaborative settings. Collaborative learning processes are essential both for promoting the intersubjective elaboration of students’ ideas and because it is a highly valued activity among scientists, through peer review and constructive feedback opportunities. Collaboration, and in particular, asynchronous collaboration, requires tools that can scaffold it. As such, web technologies are amenable to supporting students’ synchronous and asynchronous communication. However, one cannot assume that the presence of technological supports will simply make collaboration happen, as the pedagogical framework or model in which collaborative learning efforts take place greatly decide the success of these efforts.

Scaffolding (Wood et al., 1976) is based upon the work of Vygotsky, and can be defined as the support that one receives from a more knowledgeable adult or peer to help them move within their zone of proximal development and engage in activities that would have been challenging, if not impossible, without this support. Ultimately, scaffolding should fade as the learner becomes able to perform the same or a similar activity on their own. We view the classroom as a complex system where scaffolding provided by the technology, by the teacher and peers needs to work in synergy. This scaffolding is faded in the sense that students may depend on it more at the beginning of the investigation to help them organize their ideas and may gradually internalize it.

The STOCHASMOS (Kyza & Constantinou, 2007) platform is comprised of two environments: the teacher authoring environment, in which teachers can build or customize multi-modal, web-based inquiry environments, and the learning environment for the students, where students can collect and organize data, explain their thinking, interpret data, construct, and communicate explanations of the data. An important aspect is the integration of activities such as data organization, evidence identification, articulation, and reflection from the beginning of the students’ inquiry, through an area we call reflective workspace. This workspace builds on work around the Progress Portfolio (Loh et al., 1997), a stand-alone, inquiry-support software tool that provides a separate space where students can organize data, and are prompted to explain their reasoning while making connections to the data they can use as evidence in support of their ideas.

The project management features of STOCHASMOS allow teachers asynchronous access to their students’ work. This means that a teacher can review a group’s work and add comments to their WorkSpace pages, thus providing feedback the students can view and use at the beginning of their next investigation session. Furthermore, the history log of the tool can give teachers information on which inquiry environment pages the students have visited and the time between accessing each of the web-pages stored in the STOCHASMOS system.

Methods and samples
The project methodology is based on the idea of design-based research (Barab & Squire, 2004; A. L. Brown, 1992; Collins, 1992). The design-based approach seeks to bridge the often disconnected worlds of academia and theory with the realities, complexities, and constraints of educational practice. The learning environments will be iteratively tested and refined, first as pilot projects, then during local implementations, and finally during implementations and synthesis work at the European level. In the context of this approach, we will follow a mixed-methods approach, which will include qualitative and quantitative data collection measures.

During the first phase, each partner will use the learning environment with local teachers and students. During the second phase, each partner will use at least one of the interactive learning environments developed elsewhere and will provide the original designer/partner team with feedback on the implementation and learning outcomes. Through this work, we will be able to identify the critical attributes, the important constraints and the crucial characteristics of successful teaching activities that have evolved out of research-based initiatives.

Results
The specific research questions agreed upon in the project and the developmental work of the learning environment in Kristianstad, Sweden are discussed. At Kristianstad we are working with secondary students (8th-9th grade, 15-16 years) and the teaching environment will have driving questions like: Are we alone in the galaxy, or are there other intelligent beings out there? Is terraformation of Mars an option for mankind?

We have a research interest that prompts the inclusion of the following, i.e. aspects that are part of the learning environment and evaluated by the research, see also Hansson & Redfors (2007). That

- students live their life in society and have a specific worldview that influences the presuppositions they see as necessary for science
- students tend to associate additional presuppositions with scientific theories and this influences their interest in science
- critical evaluation of scientific data and reports in relation to scientific theories is of central importance.
Through analysis of video recordings and specific paper and pencil tasks we investigate
• the presuppositions that students and teachers associate with science in our contexts
• what kinds of evidence based arguments the students use in their discussions with peers in groups
• views on scientific theories that follow the teachers’ teaching as companion meanings, and correlate these views
with learning outcomes and students’ interests/attitudes.

Conclusions and implications
There are many constraints in educational systems that are diverse at the local level: curricula, assessment emphases and
procedures, pedagogies, support measures for teachers and teaching, textbooks and curricular resources, accessibility
to materials and online resources, use of resources. Because of the local differences, it is impossible to develop a unique
educational solution that can solve the problem through implementation everywhere. Likewise, it is also close to
impossible to transplant existing initiatives from one educational context to another and anticipate a similar degree of
success.

This project is an activity that concentrates on the co-ordination of the development of web-based inquiry materials with
rich scientific data regarding socio-scientific debates. The purpose of the co-ordination efforts is to combine knowledge
acquired by diverse players functioning culturally and educationally in diverse educational systems and use lessons
learned in these situations in the design of novel environments that appear to have the capacity to support meaningful
and motivated science learning. Furthermore, in this project we enact each specific learning environment with similar
populations of students in at least two countries, collect data, and use these data to further probe mechanisms for
supporting successful inquiry science learning, hence the project takes place at the international level.

References
1-14.
Carey, S., Evans, R., M. Honda, E. J., & Unger, C. (1989). An experiment is when you try it and see if it works: A study of
grade 7 students’ understanding of the construction of scientific knowledge. International Journal of Science
technology (pp. 15-22). Berlin, Germany: Springer.
California, Berkeley, CA.
Hansson, L. & Redfors, A. (2007). Upper secondary students in group discussions about physics and our presuppositions
Cyprus: Learning in Science Group.
Unpublished Ph.D. dissertation, Northwestern University, Evanston, IL.
Sciences, 12(1), 5-51.
Sjöberg, S., & Schreiner, C. (2006). How do learners in different cultures relate to science and technology? Results and
perspectives from the project rose (the relevance of science education). Asia-Pacific Forum on Science Learning
and Teaching, 6(2), 1-17.
Cognition and Instruction, 16(1), 13-117.
Allied Disciplines, 17(2), 89-100.
Puppets and engagement in science

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Background, aims and framework

The PUPPETS project is a research and development project that aims to help teachers provide more opportunities for productive talk in science lessons, using puppets as a stimulus. The research examines the effectiveness of hand-held puppets for engaging primary school children's attention, challenging their ideas and promoting learning conversations in science.

The value of talk in children's learning is well-documented. Vygotsky's (1978) work on language and social interaction has been built on by Mercer and his colleagues in their research into classroom interactions (Mercer, Wegerif & Dawes, 1999). These and others have found that talking about their ideas helps children to clarify their thinking and develop their capacity to reason (Kuhn, Shaw & Felton, 1997; Venville, 2002). The amount and nature of children's talk in science lessons depends on decisions made by the teacher. The opportunities provided for talk, the stimulus to generate talk and the learning environment to support talk are all determined by teachers. However, research such as that by Newton, Driver and Osborne (1999) indicates that in many science classrooms teachers do not create circumstances that maximise children's talk.

In our initial research we set out to investigate whether the use of puppets can provide a stimulus that will generate the kind of talk that helps thinking and reasoning in science. We aimed to help teachers enhance their practice, by increasing the opportunities for children's talk that promotes thinking and reasoning, and becoming more dialogic in their teaching (Alexander, 2006). The initial research questions were:

1. In what ways can puppets be used to enhance children's engagement and promote learning conversations in science?
2. Is it possible to change teachers' beliefs about the value of children's talk and their management of talk in science lessons?

These research questions have been reported on elsewhere (Naylor, Keogh, Downing, Maloney, & Simon, 2005; Simon, Naylor, Keogh, Maloney, & Downing, in press). The outcomes were extremely positive, raising the question of how generalisable the outcomes were and whether teachers not involved in the research could be empowered in a similar way. In our more recent research, reported on here, we therefore analyse further the role of the puppet in engaging children in science lessons, using a case study approach based on demonstration lessons.

Methods and samples

The initial research included a pilot study, to explore the suitability of the puppets for a variety of ages and to develop an analytical framework for discourse. An analytical framework was developed using an open-coding approach (Strauss & Corbin, 1998), and refined during the research. In the main study teachers were video-taped teaching science lessons with and without puppets, so that the impact of the puppets could be determined.

Since the main study we have continued to collect data on the impact of the puppets. Data collection methods have included lesson observations, interviews with teachers and written feedback from teachers. The case study reported on here involved a series of five demonstration lessons using a puppet, taught to children aged 6 – 9 years. The lessons began with an expert teacher introducing the puppet to the children, then explaining that the puppet had a problem. The puppet went on to describe its problem, then ask the children for help. The children discussed how they could help to solve the problem, then explained to the puppet how they thought the problem might be solved. Each of the five lessons were observed by approximately 30 - 40 primary school teachers (Total number = 178), who discussed what they had observed, attempted to identify significant factors in the development of the lesson, and then provided oral and written feedback.

For example, in one lesson the puppet's problem was explained through a short story about an 'ice bird' that had laid some ice eggs, and Ricky (the puppet) didn't know how to stop the eggs melting. Ricky asked the children for help in solving his problem. This led into a short practical activity to find out how to stop the eggs from melting (i.e. identify a good thermal insulator). A short plenary discussion concluded with the children explaining to Ricky what to do with the eggs to keep them frozen.
Results
All of the teachers commented favourably on the impact of the puppet; no teachers indicated that the puppet’s impact had been anything other than very positive. There was widespread agreement that the children were highly engaged by their conversation with the puppet; motivated to solve the problem presented by the puppet; and keen to let the puppet know what they had found out. Teachers were keen to go back to school and work with their own children, using a similar approach to teaching and learning science. Comments from teachers included:

This was a very motivating session.
Throughout the whole presentation the children were transfixed; their eyes never left the puppet’s face whilst it was speaking.
The children spoke directly to Ricky (the puppet) and . . . the puppet echoed their thinking . . . and spoke encouragingly to the children.
The children were focussed on the task in hand and worked quickly . . .
The children were highly focused on the follow up practical activity. They stayed on task and worked with a clear sense of purpose to solve the problem.

These comments are consistent with data from the main study, which showed that puppets can have a positive impact on children’s engagement and motivation.

Through discussion and feedback teachers identified a number of factors as relevant to the high levels of engagement shown, including:

• The puppet character, and the story it told, made the problem an authentic problem that children were keen to solve in order to help the puppet. Because children saw it as a real problem, they were highly motivated.
• The everyday situation described by the puppet made links with the children’s personal experience.
• The puppet suspended judgement about the children’s ideas, which encouraged them to explain, to justify their ideas and to find out more in order to convince the puppet.
• The puppet was viewed as a peer by the children, which enabled the teacher to present ideas through the puppet that children would not readily accept from the teacher.
• The puppet’s role was to be uncertain and unsure about what to do. Because the puppet did not understand, the children felt that they had to help him.
• Teacher intervention was minimised, which gave the children space to think about how they might solve the problem. Devising their own solutions to the problem helped to keep them focused and motivated.

Conclusions and implications
The case study confirmed the positive impact of using puppets in science lessons, even in the rather unusual circumstances of children being observed by a large group of teachers. Several factors, especially those relating to the role of the puppet and the teacher, were identified as significant in maximising the impact of a puppet. Children appeared to empathise with the puppet, to feel a degree of responsibility for it and to want to share their knowledge and expertise with it. This appeared to create the circumstances where children had a strong sense of purpose for their scientific activities and took a greater responsibility for their own learning.

The case study lesson was very positively received by the teacher observers. It suggests that this may be a viable model for teacher professional development, providing a possible mechanism by which the very positive results of the main study might be used to influence professional practice. Although the teacher demonstrating needs a high level of expertise (and confidence), it closely models an authentic classroom experience and provides teachers with a common basis of evidence for discussion and reflection. Further feedback will be obtained regarding the extent to which the teacher observers go on to adopt similar approaches in their own teaching.

References
International Journal of Science Education.


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Resources for learning science in schools

Popularity and relevance of science education and scientific literacy

The PARSEL Project in Europe

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Background, aims and framework

The European Commission concern ‘Europe needs more scientists’ (2004) was recently supplemented by the call for “Science now” (Rocard et al., 2007). Our societies, regardless of any cultural differences, need scientifically literate citizens (Bolte, 2003, 2007; Brown, Reveles & Kelly, 2005; Bybee, 1997; DeBoer, 2000; Fensham, 2004; Holbrook & Rannikmae, 2002; National Research Council NRC, 1996). This is seen as being broadly consistent with the EU’s Lisbon agenda - to become the world’s most dynamic knowledge-based society. Scientific literacy furthermore stresses the social dimension, which is ...

- the capacity to use scientific knowledge to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. (OECD, 2003)

Other definitions go further and include everyday life relevance (Bolte, 2006; Holbrook & Rannikmae, 1997) and responsible citizenship (Zeidler, Sadler, Simmons & Howes, 2005). Unfortunately research shows a decline in interest in science among students, especially girls (Bolte, 2006; Gräber, 1998; Sjøberg, 1997).

A consortium of researchers from eight European nations launched the PARSEL project in order to:

- Attempt to create a network community from those working on the same topic to develop relevant and interesting teaching-learning materials
- Assemble notions of ‘best practice’ from the diversity of considerations by partners
- Develop a model which encompasses philosophical consideration, learning theories and teaching approaches
- Modify existing exemplars, as appropriate
- Evaluate examples in the practice
- Make best practice teaching-learning materials available in a range of European languages.

In a first step the crew collected 54 modules of creative science teaching, due to innovative science teaching programmes and existing experiences (Hofstein, Navon, Kipnis & Mamløk-Naaman, 2005). Other considerations are made on strategies to implement the PARSEL-Modules into teachers’ professional work (Michelsen & Lindner, 2007).

Implications

The materials go beyond scientific problem solving (even where this leads to “applications” in real life), or promotion of the nature of science. This is seen as a key feature of the model. The intended theoretical underpinning of the materials and hence the structure of the model is activity theory as described by van Aalsvoort (2004). For material to have relevance it is seen as essential that the learning meets a need, as perceived by the student, and involves motives that enable students to recognise the relevance of the learning to their lives. The model perceives the importance of initiating the teaching from real life and then pursuing the science and excluding material (especially based on the title of teaching materials) which initiate the learning through a scientific approach. The model shows this as step 1.

Step 2 is familiar to science teachers and reinforces the inquiry type investigatory approach to higher order conceptual learning, the gaining of process skills and an appreciation of the nature of science pertaining to the area of study. The key aspect in the model is that step 2 is not the first stage and its inclusion is dependent on the real life situation starting point and the conceptual science learning boundary is given by the real life situation being studied. Step 2 thus provides the background needed by the student in order to be able to appreciate the scientific background for a better understanding of the real life situation. It enables decisions to be made built on sound scientific conceptual understanding and, if the higher order teaching has been successful, to transfer the learning to the new situation. Step 2 is thus a major component of PARSEL material, but is derived from a real life, not a scientific, introduction.

If step 2 is familiar to the teacher, step 3 is much less so. This step recognises that real life situations rarely involve scientific components in their resolution and that socio-scientific argumentation plays an essential role. Step 3 thus recognises the need for science education to reach out to the real world and meet educational goals as befit a school subject which is trying to educate students. This education is more than conceptual understanding and extends to personal and social development within a science context. Step 3 recognises this and provides the opportunity to return to the real life situations from step 1 and to pursue this into decision making using argumentation teaching approaches. These bring social factors and the application of the conceptual science together.
The model is put forward in 3 steps as an approach towards ensuring the popularity and relevance of science education and specifically helping students to enhance their scientific literacy for adult life, whether this be for further education, a career, or for being a responsible citizen. The model recognises that scientific literacy is for all.

References


Investigating teacher and student understanding of the purpose of experimental work in physics
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Background, aims and framework
Lee Shulman introduced the term Pedagogical Content Knowledge (PCK) in his famous paper in 1986 (Shulman, 1986). The term has been widely accepted among science education researchers, even though there have been discussions on how to interpret and measure PCK (Gess-Newsome & Lederman, 1999; Lederman & Gess-Newsome, 1992; Loughran, 2005; van Dijk & Kattmann, 2006; van Driel, Verloop & de Vos, 1998; and others).

This study is an investigation of two experienced physics teachers and their way of articulating their aims and purposes for an experimental module in Danish upper secondary school. The definitions of ‘aim’ and ‘purpose’ used are found in the article by Hart, Mulhall, Berry, Loughran and Gunstone, from 2000: ‘Purpose’ is defined as the intention the teacher has for the activity when she/he decides to use it with a particular class at a particular time. ‘Aim’ is the often quite formalised statement about the intended endpoints of the activity.

Internationally there is a vast amount of literature discussing the goals and reasons for experimental work in the school subject physics. Lavonen, Jauhiainen, Koponen and Kurki-Suonio (2004), have made an extended literature review of reasons for experimental work, giving the following list from a variety of people like Hodson, Gott, Duggan, Wellington, Confrey, Millar, Wilkinson and others: Better acquisition of scientific knowledge, better understanding of the empirical nature of the natural sciences; developing different work or process related skills (measuring and designing an investigation); better attitudes and motivation to study science; enhancing personal growth by conducting experiments in the classroom; increasing autonomy when engaged in open-ended problems; connecting learning with concrete experience and more. This list is general and does not refer to special subjects within physics. If a teacher is asked generally for the reasons for experimental work in physics, parts of the above list might be given - not necessarily connecting it to their own teaching. Therefore I find it necessary to study specific experimental modules and question the teachers for their purpose(s) of their specific modules to make it more likely that the answers are connected to the action in class. I am not looking for a teacher’s list like the above, but I wish to investigate how teachers define the purposes of their experimental modules, and what impact this has on the students’ motivation and learning.

Methods and samples
The teachers were interviewed prior to the modules. Teacher 1 was teaching the ideal gas law, and teacher 2 was teaching conservation of mechanical energy. The teachers were asked for purposes for the lesson series and how these ideas were developed. The topics of these two lesson series are quite different and draw from different parts of the physics curriculum. I found it important to let the teachers choose the topics themselves, thereby giving me the chance to investigate practical work, which is special to the teachers, thereby increasing the opportunity for the teacher to show me an experiment, where he/she has given the purpose a great deal of thought.

The modules of the two different teachers were videotaped. During the practical work, both teachers had divided the class into groups of 2-4 students. During the practical work, the students worked from a teacher-written guide, and each practical work was run like a cook-book exercise with almost no freedom of choice in the performance of the practical work. Both teachers circulated, helping with practical problems and answering questions during the practical work. The students’ work with the laboratory equipment was videotaped, and they were interviewed in their groups immediately after the laboratory work. The students’ experimental reports were collected after correction by the teacher.

In Danish upper secondary school (year 10-12) the subject physics is optional in year 11 and 12. Practical work has a rather high priority in the physics class. These particular classes are year 11 students with physics on level A or B, which means they have chosen physics beyond the obligatory level. Most of the students have also chosen mathematics on level A. When asked for the future plans for education, most of the students had no intention of studying a subject where physics on a high level was compulsory; only a small percentage had the intention to study physics or physical engineering at tertiary level. The teachers have been teaching physics the last 15 and 35 years, respectively, both having taught the chosen topic many times before.

The data consist of pre-interviews with the teacher, the teacher-written guide to the practical work, video-recordings of the lessons and the practical work, student interviews, written reports and the teachers’ comments to the reports. A list of possible purposes for the topics was made, each purpose categorized as knowledge, competence and understanding (including meta-understanding and nature of science). A triangulation between the possible purposes of all these different data formats were done, showing where and to what extent the purposes correlate.
Results

During the pre-interview with teacher 1 she states that this specific module on the ideal gas law has been included in her teaching of year 11 physics a number of times, and she explains, each year the module is modulated to fit the class and is changed based on experiences from the previous years. The development of the purposes of the module has evolved during time, and it would be impossible to start out a new module with a clear plan for the purpose. This teacher hereby states that her PCK is bound to specific modules/topics, and it is necessary to teach the same module a number of times to develop and articulate the purpose of the activity. She also states that not all her modules have a clear purpose, since it demands a lot of thinking to fully grasp the possibilities within a module.

The teacher explains her purposes of the module: knowledge of the ideal gas law; skill training of graphical interpretation of data; and introduction to variable control. By variable control the teacher explains, in this example, the need to keep two of the four variables in the ideal gas law constant, change the third variable and measure the fourth, since changing three variables at once and measuring the fourth will not give the students the possibility to extract the ideal gas law from the data set. Introducing the topic to the students, the teacher writes her purposes for the module on the board. After this introduction, the list is no longer mentioned in the class, but many indirect references can be found in the teacher’s statements in class and in the guide to the practical work. The laboratory work included three experiments to be performed, which combined makes it possible to extract the ideal gas law. When asking the students, at the interview by the end of the module, what the teacher wanted them to learn, both interviewed groups were able to explain the teacher’s purposes of the module. One group referred to the teacher’s introductory list on the board, while the other group apparently had forgotten the teacher’s list but was able to explain the three purposes with their own words. The purposes stated by the teacher are again found in the students’ reports.

During the pre-interview with teacher 2, the purposes of the practical work are not prior articulated by the teacher. Clearly this teacher finds no need to articulate the purposes for his practical work beyond the aim of teaching conservation of mechanical energy, and the related physical concepts involved in this. He has a less articulate understanding of his own development of PCK. Still he explains he changes the lessons of this topic according to the interests amongst the students of the class. From the video-recordings of the lessons and the written guide, it is clear that the teacher could be using this topic to teach the students about units, uncertainties and reliability of data. The practical work involves a measurement of the change in kinetic and potential energy of a system containing a cart on a hover bench, being pulled by weight, connected to the cart by a string moving over a pulley. In the student interviews none of the students were able to explain what the teacher wanted them to gain from the practical work, besides the aim of learning about conservation of mechanical energy, and this is again found in the reports.

Generally both classes consist of highly motivated and skilled students. Both students comment on their teacher in a very positive manner.

Conclusions and implications

This synopsis is the introductory work of a larger study of teachers’ abilities to declare the purpose for specific experimental activities, both for themselves and their students. The investigation will lead to an analysis of the students’ understanding of the teachers’ purpose and the connection to their motivation and learning outcome of the experimental work.

The students of the two classes were given a traditional task of a closed experimental exercise, which is often highlighted as boring, lacking learning outcome and giving the student poor chances to gain ownership of the task. Both classes replied positively on the task, showing high motivation of each group. But it was quite different what the students of the two classes learned. The class of teacher 1 learned, beside the aim of knowledge of the ideal gas law, variable control categorized as nature of science, along with the competence of graphical representation. The class of teacher 2 learned the aim of knowledge of conservation of mechanical energy, but there are not clear correlations among the students of any understanding of nature of science or gaining of competencies.

From this study it is clearly found, that the students have a remarkable sense of understanding the intention the teachers have for the practical work. If only the aims are found important by the teacher, then only this is found in the work of the students. If the teacher is using the practical work to teach the students competencies, understanding and meta-understanding, and nature of science, then the students realize these purposes and try to learn according to them.

If this conclusion is valid in future investigations, this demands teachers to be aware of their purposes. It might seem a fairly easy task, but based on this study, literature studies of PCK and other qualitative investigations, it takes experienced teachers with a large degree of content knowledge, pedagogical content knowledge and understanding of the possible purposes of the practical work to fully grasp the possibilities, that lie within a curriculum requested task.
Kan web-logg brukes for å koble praktisk arbeid til arbeid med teoretiske begreper?

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Innledning

Disse forfatterne beskriver betydningen av diskusjoner i klasserommet som læringsarena. Imidlertid er skolenes IKT-park i dag så god at man kan inkludere bruk av internett-basert kommunikasjon for også å legge opp til diskusjoner mellom elever på ulike skoler, både i eget land og i utlandet. Bruk av IKT aktualiseres videre ved at det er et kommunikasjonsmedium som de fleste elevene er svært godt kjent med og liker å bruke. I tillegg skriver de da for et reelt publikum, ikke kun for en lærer som skal etterprøve hva de kan. Dette kan fremme motivasjonen for å gå inn i faglige diskusjoner. Bruk av web-logg gjør det dessuten lett for læreren å følge elevenes utvikling i bruk av begreber, på samme måte som ved skriving av logg, og å bruke dette i den videre undervisningen av faglige emner knyttet til et gitt tema.

I studiet som her blir diskutert, arbeidet elevene praktisk innenfor teknologi og design med å konstruere et fartøy som kunne kjøre på is og drives av vind. Samtidig skulle de beskrive sine planer og sin arbeidsprosess på en web-logg som ble laget spesielt til arbeidet med prosjektet. Teoretiske emner som det var naturlig å arbeide med knyttet til konstruksjonene, var friksjon, energi og vindkraft.

Studiet er en del av et større samarbeid med skoler i Australia. Dette krever at elevene kommuniserer på engelsk, noe som selvfølgelig var en ekstra utfordring for norske elever. Australia er interessant å sammenligne seg med siden de har et vestlig skolesystem, etter modell av det britiske, men de greier seg likevel bedre enn de fleste vestlige land i de store internasjonale undersøkelsene (Kjærnsli, et al., 2007).

Studiet omfatter først en utviklingsdel der et elevprosjekt med webbasert kommunikasjon mellom elevene ble utviklet. Med basis i arbeidet med disse elevprosjektene stilte vi så følgende spørsmål:

- Er det forskjeller mellom elevene i Norge og Australia i bruk av bloggen?
- Hva kommuniserer elevene på nettsidene?
- Bruker lærerne elevenes praktiske arbeid med å bygge fartøyer og deres web- kommunikasjon som basis for å arbeide med teoretiske begreper?

Material og metoder
Skolene som var med i den norske delen av prosjektet er:

- en 1-7 skole i Alta der en elevergruppe på 25 elever på 6. årstrinn var med.
- en liten 1-10 skole utenfor Hammerfest der 3.–7. årstrinn deltok i arbeidet med prosjektet, til sammen 15 elever.
Materialet som her blir presentert, består av en kvalitativ vurdering av elevenes bruk av web-loggen, samt en analyse av innholdet i elevenes beskrivelser på bloggen som blir klassifisert i fire kategorier i samsvar med Lloyd og Duncan-Howell (2008). Disse er:

- Deskriptiv beskrivelse av aktiviteten
- Planer for videre arbeid (viser at elevene er inne i en designprosess)
- Beskrivelse av utprøvninger
- Beskrivelse av samarbeidet i gruppene

I tillegg ble involverte lærere intervjuet etter at elevprosjektene var over. Fokuset var hvorvidt lærerne hadde lagt opp til faglige diskusjoner i tilknytning til elevenes praktiske arbeid.

**Resultater**

Det ble utviklet en hjemmeside for prosjektet:  

Dette er en omarbeidet versjon av den australske hjemmesiden:  


Elevene brukte informasjonen på hjemmesida som utgangspunkt for byggingen og fulgte kravene som var satt der. En av skolene, den med 15 elever, brukte ikke blogg funksjonen. Elevene ved den andre skolen brukte bloggen som en ordinær logg i etterkant av utført arbeid.

Angående innholdet i elevenes blogg så var 45% en deskriptiv beskrivelse av arbeidet de hadde gjort, 23% beskrev planer for videre arbeid, 3% beskrev utprøvninger og 29% fokuset mest samarbeid i gruppene. Elevene har i liten grad gitt skolevitenskapelige forklaringer som begrunner deres valg og problemløsninger.

Lærerne diskuterte i oppstarten av prosjektet hvilke materialer som gav ulik grad av friksjon. Ut over dette ble ikke elevprosjektene brukt til lærerstyrt arbeid med faglige begreper.

**Diskusjon og konklusjon**

De norske elevene forholdt seg til web-loggen på en annen måte enn de australske (Lloyd & Duncan-Howell, 2008), ved at de australske elevene i større grad brukte bloggen som et diskusjonsforum. Vi ser to mulige forklaringer på dette. De involverte norske skolene har lang erfaring med at elevene henter informasjon fra nettet, men de har liten eller ingen tradisjon for at elevene bruker nettet interaktivt i forbindelse med sine prosjekter. Dette argumentet blir forsterket av at engelsk kan være for vanskelig for flere av elevene å kommunisere på i faglig sammenheng. Den andre forklaringen er knyttet til at vi hadde tekniske problemer med bloggen i begynnelsen av prosjektet. Elevene måtte derfor i starten skrive sine kommentarer på skissene de lagde. Det kan ha ført til at det ble mer naturlig for de å fortsette med papir og blyant også utover i prosjektet.

Angående innholdet i elevenes blogger så fant vi et samsvar i fokus mellom elever i Norge og elever i Australia ved at elevene i begge land fokuset beskrivelse av det de hadde gjort i arbeidet med fartøyene og de fokuset samarbeidet de hadde i gruppene (Lloyd & Duncan-Howell, 2008). Imidlertid fokuset norske elever sterkt sine videre planer for arbeidet mens de i liten grad la vekt på å beskrive utprøvingene de eventuelt hadde gjennomført. Dette forholdet var omvendt for de australske elevene.


**References**


References
Selected aspects of virtual laboratories and remote experiments
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Introduction
One of the intellectual challenges when learning physics is to understand the role of a physical theory, the role of a physical model and the role of an experiment. Often, these terms are intermixed, and the classical curriculum offering separate lectures for theoretical and experimental physics does not make it easier for students to really comprehend their interrelation.

Modern eLearning technology may act as a bridge: on the one hand, computer systems make real experiments available over the internet, anytime, anywhere, and even more important make the measured data electronically available for further analysis. On the other hand, a model for an experiment can be implemented as a simulation within a virtual laboratory, making the same physical quantities available for measurement as in the “real” experiment. It is now straightforward for a student to compare the outcome of the two approaches and to compare them again with an analytical result of a physical theory. Thereby, similarities and differences between the theory, the model and the experiment can be demonstrated and analyzed.

In this paper, we discuss two important physical systems. Firstly, the physics of ferromagnetism and the Ising model [1] as the most prominent system of statistical mechanics. Second, the physics of ideal gases, and, as the corresponding theoretical model, the lattice gas model [2,3] to discuss the concept of entropy phenomenological as well as statistical thermodynamics.

Related works
Remote experiments and simulations are actively used in various experimental sciences, related training courses have also been explored in chemistry, see e.g. [14] and electrical engineering, e.g. by [15]. However, the relation between experiment and simulation is rarely stressed. The combination of complementing virtual labs and remote experiments supports the analysis of a given physical phenomenon from different angles. The capability of remote access through the Internet allows the student a direct comparison of theory and model on one hand and experiment and physical reality on the other without having to switch back and forth between library or Internet and the laboratory. An interesting and related setup is the remote experiment and virtual lab for wind tunnels developed by Esche et al. [16], a virtual laboratory for exploiting DSP algorithms [17], and a learning tool for chip manufacturing [18]. Virtual labs are also explored as on-shore educational tools to train the technical skills of sailors of the US navy, see [19].

Magnetism in virtual laboratories
The Virtual Laboratory VideoEasel developed at the TU Berlin focuses on the field of statistical physics and statistical mechanics [7,8]. Implementing a freely programmable cellular automaton [9], VideoEasel is capable of simulating various models of statistical mechanics and related fields.

Measurements are performed by tools freely plugged into the experiment by the user, allowing to observe magnetization, entropy, free energy or other measuring quantities. When experiments of higher complexity are performed, the experimental results can be automatically exported into computer algebra systems for further analysis. To enhance cooperative work between students, or students and their teachers, VideoEasel is able to support distributed measurement processes on the same experimental setup, including remote access from outside the university[7].
To investigate the Ising model, VideoEasel implements the Metropolis dynamics (Figure 1) [10]. A spin is drawn at random, and flipped if either the overall energy of the model decreases after the flip, or the energy can be borrowed from a heat-reservoir. The user is able to control the temperature $T$ and external field $H$ and then measures quantities as the magnetization $M$. If we plot the relation between $M$ and the field $H$ for low temperature, a hysteresis loop is found (Figure 2). For high temperatures this figure vanishes.

Additionally, our model allows us to measure an additional parameter, namely the Helmholtz Free Energy $F$ [11]. This quantity is phenomenologically defined as the fraction of the overall energy of the model that is available for mechanical work. If we measure $M$ and $F$, each depending on $H$, while starting from a random spin configuration, we get the graphs shown in 3. It is now easy to conjecture for our students that $M$ must be proportional to the negative derivative of $F$ with respect to $H$. After having seen that, our students easily derived this from the Gibbs state of the Ising model [11], and thus our experiment was also didactically successful.

Investigating hysteresis in remote experiments

Complementary to virtual laboratories, remote experiments are real experiments, remotely controlled by the student from outside the laboratory. A remote experiment consists of two vital parts, namely the experiment itself and a computer interface allowing control over the experiment via the internet. For the latter, we use National Instruments LabView [12], which also provides a convenient web-interface. In order to view and control the experiment, a freely available web browser plug-in has to be downloaded and installed. Due to the modular programming structure of LabView, remote experiments can easily be combined or extended [13].

We can now run the same experiment, namely that of measuring the hysteresis loop of magnetization vs. magnetic field, in reality: a magnetic coil generates a magnetic field $H$ that is proportional to the current passing through it, which is controlled by the computer. The magnetic field magnetizes a ferromagnetic core. The magnetic induction $B$ is measured by a Hall probe (Figure 4). The measured value is then digitized by an analog-digital converter that provides a digital output port, and by that made available from the computer system.
Virtual laboratories and remote experiments: similarities and differences
At first glance, both the experiment and the model show the same hysteresis effect: the relation between magnetization and magnetic field cannot be represented by a function. However, a student running both types of experiments will note that the exact shape of the hysteresis loops is very different: Whereas the Ising model shows an almost rectangular shape (Figure 2), textbooks typically show an S-shaped form. But even the usual graphs found in textbooks do not always depict reality correctly: The hysteresis loop has a small area (Figure 5). Thus experiment and model do not agree completely.

There are also deviations between model and theory: When taking the numerical derivative of the free energy, the curve looks almost, but not quite like the magnetization plot: The derivations are best seen for small fields. This is likely because our entropy measurement is only an approximation and does not take long-range interactions into consideration.

Students, in this way, learn that models are by their very nature incomplete, and theories make approximations and can only predict reality within a certain error.

A brief introduction to thermodynamics
Thermodynamics is the physics of temperature and heat. As a phenomenological science, it formulates the relations observed between physical observables. For example for the ideal gas the product of pressure and volume is proportional to the temperature. Thermodynamics does not attempt to derive these relations from a microscopic theory.

Even though these relations are obvious to verify in an experiment, thermodynamics also formulates laws that are harder to verify experimentally. The most prominent example is the second law of thermodynamics, first formulated by Clausius [20], which states the existence of a thermodynamic potential called the entropy, which cannot increase in closed systems. One of the consequences of this law is that thermodynamic processes, e.g. combustion engines transforming heat into mechanical work, must have a limited efficiency strictly below 1. Said another way, it is impossible to convert heat energy into mechanical work without any loss [21] of temperatures $T>0$.

Since entropy is a rather abstract concept that cannot be measured directly, this law is, almost traditionally, hard to motivate to students. Some textbooks even joke that “students usually only believe this law because they wouldn’t otherwise pass their exam” [22].

Phenomenological thermodynamics in the remote experiment
To demonstrate the classical gas laws, our remote experiment farm also includes an experiment on thermodynamics (Figure 6). A motor controls the position of a piston in a glass cylinder containing air whose temperature can be remotely adjusted by a heater. Sensors measure the pressure of the gas and its temperature. Their measurements are digitized and made available over the internet. Given this setup, students can readily verify the classical laws of phenomenological thermodynamics, for example the Gay-Lussac relation between volume and temperature.
However, one can clearly go beyond this experiment: By controlling the heater and the piston, students can run the system in a thermodynamic cycle process. The amount of heat energy induced is known due to the characteristics of the heater, and the amount of mechanical energy made available by a cycle can be computed from the area within the $pV$ diagram [22] as measured, (Figure. 7). Comparing the two readily presents the limited effectiveness of the process, and demonstrates one of the consequences of the second law of thermodynamics.

**Lattice gases in the virtual laboratory**

Lattice gases are simple, discrete models for ideal gases defined as cellular automata [9], and as such easily implementable in our virtual laboratory. Within HPP model used by our setup [23, 24], the gas consists of elementary particles, atoms called in the following, which can only travel in four diagonal directions within two-dimensional space. Collisions with boundaries and between atoms preserve energy and momentum.

Unlike in remote experiments, we are now in a position where we know the microscopic state of the system exactly, and are thus able to measure the entropy. In a simple experiment, a student fills one corner of a simulated gas container with the lattice gas. If the simulation is run, the gas expands into the entire container and the entropy increases except for some small derivation, see Figure. 9.

**Figure 6** The hysteresis loop, as found by the remote experiment.

**Figure 7** A $pV$ diagram, as measured by the remote experiment.
The monotonicity of the entropy looks even more surprising if we recapitulate that the elementary laws of the HPP gas are completely symmetric in time. The very same argument has been considered historically by Loschmidt as an objection against Boltzmann’s H-Theorem [25,26]: Students are now, however, in a position where this objection can be discussed within an experiment, as our virtual laboratory provides means to invert all moments. Quite as one might expect, gas atoms then move back to their initial positions and the entropy function decreases.

An experiment, whose outcome is as confusing, is well-suited to stimulate a vibrant discussion amongst our students. The resolution is now that the initial state of a gas running back into its container is extremely unlikely and with some guidance, students often come up with an experiment to justify this argument: After modifying the seemingly chaotic state by displacing a single atom by one pixel, we invert the moments of all gas atoms again and observe the entropy and the system behavior again. Even though the entropy starts to decrease for a short while, the system comes no longer close to the initial minimum, and entropy begins to increase shortly after.

Comparing remote experiments and virtual laboratories

It is worth noting that the $pV$ looks again not very much like the idealized curves found in textbooks and is rather noisy. Good textbooks like [22] will of course comment on such specialties. Similar differences often arise in real experiments, as we already found for the hysteresis experiment. They need to be discussed with the students and make up an important part of the education in physics, too.

On the other hand, we also find a tiny discrepancy between the phenomenologically formulated second law of thermodynamics and the corresponding outcome of the virtual experiment: It is not impossible that the entropy decreases, it is just that all odds are against it. Thus, the important lesson to be learned is that the second law makes a statement about the statistics of the system.

The complementary nature of remote experiments and virtual laboratories becomes even more apparent for the experiments on thermodynamics: While the remote experiment is targeted at the phenomenological side of thermodynamics, virtual laboratories allow exploring the statistical mathematical aspect of entropy. Thus, the dual nature of thermodynamical variables such as entropy - being a phenomenological quantity as well as a statistical one - can be explored and demonstrated.
Deployment and evaluation

We deployed the virtual laboratory in the course "Mathematical Physics II" at the TU Berlin. This three-semester course covers in its second semester models of many-particle physics, specifically the Ising model and the lattice gas model. Even though this course is taught in the institute for mathematics, the majority of participating students are typically physicists; the group size is typically between 15 and 20 students. While the lecture covers the theoretical aspects and the mathematical background of the models, we used the practice group of the course to guide the students to experiments on the theory discussed in the lecture before. Specifically, the Metropolis dynamics of the Ising model got introduced, the phase transition was measured on the virtual experiment and the relation between magnetization and free energy was derived experimentally. Students were asked to carry out the experiments, perform the measurements and collect all necessary data, and were requested to put this data in relation to the material learned in the lecture. To our delight, students did find the requested relation between the two quantities (see section III and Figure 3), and were able to derive them by their own from the mathematical model.

At the end of the course, we requested students to fill out an anonymous query form on the lecture and the practice group. This standard form is kindly provided by the student union of the TU Berlin, and used consistently for the evaluation of all lectures of the institute. According to this evaluation, the lecture received an average grade of 1.7 on a 1 to 6 scale, 1 being best and 6 being worst, thus placing this lecture in the best third fraction. Students appreciated mostly that they could relate the theoretical material and models to practical experience and could gain some hands-on approach on the abstract definitions learned in the mathematical course. Interestingly, the course also triggered some interest in the actual implementation and infrastructure of our virtual laboratory which we couldn’t delve into in the group due to time constraints.

Even though experiments on the lattice gas have often been demonstrated to students with great success, we have not yet had the chance to discuss the model in a similar experiment, unfortunately.

Conclusion and outlook

The accomplishment of experiments in eLearning scenarios touches many aspects of the learning process in the academic education of natural and engineering scientists, ranging from the actual quantification of a physical measurement over operating experience with real experimental setups to the examination of the corresponding theoretical model. The combination of real experiments with virtual laboratories creates many benefits, of which the most important is that we allow students to study a physical phenomenon through experiment, model and theory. We believe that the complementary nature of remote experiments and virtual laboratories stimulates the process of understanding in an outstanding manner, which is vital for the learning process in natural sciences.

Our work will also continue into another direction, namely in trying to perform experiments where virtual and real components interact, for example to compare their outcomes in a common plot within Maple, the mathematical algebra program. As both LabView and VideoEasel provide the necessary interfaces to export data, this goal seems to be in close reach.

References


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**Textbook authors’ intentions and ideas when writing upper secondary biology textbooks in relation to nature of science**

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**Background, aims and framework**

This study is part of a research project about teaching and learning genetics with a model-based approach to science and science education in which aspects of nature of science (NOS) are made explicit by the history of science. The national Swedish curricula for the science program (age 16-19) at upper secondary school (The Swedish National Agency for Education, 2007) states:

> Model thinking is fundamental for all disciplines of natural science as well as other scientific fields. In education a development of understanding that our comprehension of natural phenomena consists of models… should exist. These models change and refine as new knowledge emerge. A historical perspective contributes to illustrate the progress the science disciplines have gone through and their importance to society.

Hence, this statement emphasizes the importance of using models in NOS as well as history of science perspective when teaching science.
In a first study (Gericke & Hagberg, 2007) five historical scientific models of gene function were defined and analyzed. Each model represents a significant change in the way the function of the gene was perceived. When teaching, science models are often used. However, teachers and textbooks are not always explicit about their use of models. Instead of using specific historical models, attributes are often transferred from one model to another, resulting in hybrid models that might be difficult to teach and to learn (Justi & Gilbert, 2000). In a second study (Gericke & Hagberg, in prep.) Swedish biology and chemistry textbooks for upper secondary school were analyzed in order to find out how the description of the phenomenon of gene function was presented in relation to the historical models. A great variation was found, mainly implicitly presented. An explicit NOS perspective in the books could constitute a guide helping the students to interpret the variation, and the incommensurability that might arise from this variation.

In this study we aim at:

- finding out how and why the textbooks have been worked out as they have regarding NOS
- elucidating the authors’ intentions and ideas behind them, particularly in relation to the subject matter content of genetics.

**Methods and samples**

Five interviews were conducted with authors representing all five textbooks, which are published in biology for upper secondary school in Sweden. A semi-structured interview, consisting of three phases: a warm-up phase at the beginning, the main phase, and a debriefing at the end, was designed according to Kvale (1996). The interviews were recorded. In the warm-up phase the interviewer explained the purpose and the procedure of the interview and the authors were asked about their background. In the main phase the authors’ incentives and motives as textbook authors were discussed. Further the process behind the writing of the textbook was elucidated. The authors views of the importance and role of NOS in general and models in particular in science education were discussed. Specific citations in the Swedish curricula about these aspects were used as a starting point in the discussions. At the end of the main phase more content specific questions regarding genetics in the textbooks, and the categorization of implicit textbook models of gene function (Gericke & Hagberg, in prep.) was discussed. During the debriefing in the end the recorder was turned off and the authors were given the opportunity to comment on the content as well as the procedure of the interview. The authors again gave permission to use the recordings for research purposes.

The interviews were transcribed and validated by a second researcher who listened through the tapes and at the same time double checked and commented the transcriptions.

**Results**

The analysis is still in progress so we will here present some preliminary, tentative and general results, which we nevertheless consider interesting and worthwhile sharing with others. We expect more results to emerge from the data which then will be presented at the conference.

The results show that the textbook authors can all be regarded as very insightful in issues regarding epistemology and NOS. All of them have experiences from postgraduate studies and most of them have a PhD. They also have long personal experience from teaching. The experience from teaching was by the authors considered as a very important foundation when writing the textbooks. The syllabus in biology was mentioned as an important guideline for what content to put into the book. Though other more general elements of the curricula in which NOS aspects are manifested, such as program goals for the science program and goals for the biology subject, were not considered by the authors in the writing process instead NOS aspects were handed down to the teachers to manage in the classroom. The flexible use of the textbook was much emphasized by the authors as an important goal when writing the book, making it possible for the teachers to use the textbooks in different ways not being forced to read the book from first to last page. In the idea of flexibility most authors also included that the textbooks should be regarded as a sort of base in the classroom which the students should be able to read without any instructions. Hence most authors were reluctant to include content that does not follow the main scientific ideas. More new scientific ideas that render a greater risk of being proven wrong were therefore deliberately avoided by most of the authors. The textbook may in that case soon after printing contain errors and therefore appear out of date.

Although aspects of NOS, such as models, theories, scientific thinking etc., are rarely mentioned with explicit terminology in the books, these aspects are inevitable embedded within the content knowledge (Gericke & Hagberg, submitted). A couple of the authors say they try to hint the difference between “scientific knowledge about nature” and “nature itself” by using the language as a tool. For example instead of writing “How something is” they could write “Some researchers look on it that way and other in some other way” or “A food chain shows the energy flow in a ecosystem” instead of “The energy flows in a food chain”. Four of the authors addressed the conflict between being explicit with NOS aspects and the goal of simplify the content of the book. Several of the authors mentioned that publishers requested the authors to use scientific terminology moderately. The most important aspect of NOS emphasized by the authors is the empirical basis of biology (and genetics) and that those aspects are shown by incorporating observation and experimentation in teaching, which most of the authors equals with scientific method. In the textbooks this is manifested through short
general unites about the nature of biology and in the passages describing history of science. One textbook though contains guidelines for laboratory and experimental work. However for the other textbooks there is the possibility to buy extra materials with experiments and exercises. Other guidelines to the textbooks are scarce and general.

Conclusions and implications
The textbooks influence both the structure and the contents of the lessons in high school biology (DiGisi & Willett, 1995). Knain (2001) reported that secondary science textbooks do not present science as an endeavor involving debate and discussion. The textbooks ignored the difference between “scientific knowledge about nature” and “nature itself”. Instead textbooks often lack a NOS perspective (Gericke & Drechsler, 2006). This study shows that the authors have the ambition to make textbooks that are flexible, timeless and self-sustaining in the hands of the students. This in turn might constrain the possibility to emphasize NOS aspects in general as well as embedded in the content of the textbooks. The teachers’ knowledge and insight in NOS issues then becomes crucial since they are emphasized in the curricula. Also several of the authors explicitly said that they leave these issues for the teacher to cope with in the classroom: “I leave to the teachers to find the cutting edges themselves, which he or she finds interesting, to show off, or use the applications which are topical at the time when the course takes place.” Keeping the authors’ ideas about the use of the textbooks in mind it becomes a crucial implication for teachers to be aware of these expectations when using the textbook in the classroom, and in the same time live up to the curricula’s goals for NOS. The demand of the teachers’ comprehension about content knowledge as well as NOS is extensive and it calls for a use of the textbook that differ from most of the research results found in the literature, which say that the textbooks influence the structure as well as the content of the lessons in high school (DiGisi & Willett, 1995; Juhlin-Svensson, 1995).

However in textbook writing not only the authors’ own ideas and intentions must be considered but also the influence of publishers and editors. The editors gave much feedback on language and layout. However the authors recall only few comments about the content or issues about NOS from the editors. Other important factors determining the outcome of writing textbooks were traditions and expectations of the teachers. In Swedish schools teachers themselves determine which textbook to purchase tending to conserve the structure and the content of the books, since teachers prefer books they can recognize.

References


Argumentative reasoning in peer groups – conceptual issues and epistemological underpinnings
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Background, aims and framework
Argumentation in school science settings is of growing interest, especially the value of argumentation for unpacking the nature of claims and warrants for knowledge (Kelly, 2007, p. 453). In argumentation it is possible for the learner to elaborate and coordinate both cognitive and epistemic goals (Erduran, Osborne & Simon, 2005). It is through argumentation that reasoning and knowing become accessible, both to the learners themselves and to others and then it could enhance the possibilities to perform assessment for learning (Black, Harrison, Lee, Marshall & Wiliam, 2003). The skill to choose from different explanations following a discussion is a discursive practice essential in building scientific knowledge according to Jiménez-Aleixandre and Pereiro-Muñoz (2002). Analysis of argumentation is often done in relation to socio-scientific issues. However, this study’s analysis is towards a specific content, the evolution of life on Earth. It is a topic that could challenge our ontological views, as well as our understanding of evolution. Like other topics it depends on a
number of conceptual issues and their epistemological underpinning. Students’ conceptions about evolution have been investigated thoroughly through individual writings and interviews (Thomas, 2000).

The aim in this study is to investigate conversations in peer group discussions with focus on argumentation patterns towards a substantive content issue; the origin of variation. The aim is to put students’ own wording in the foreground; what students perceive as important conceptual and epistemological issues. The specific research questions are:
- What conceptual issues are articulated and made important by the students?
- How do students justify and support their claims about the origin of variation?

Methods and sample
The empirical data is generated through a group discussion between seventeen-year-old students attending the natural science programme at a Swedish upper secondary school. They are taking part in a teaching-learning sequence about biological evolution. It is their third lesson, the previous two have dealt with genes, inheritance, cell division, mutations and the common descent of life. The context is an ordinary lesson with three group tasks that the students move between. At one station they are supposed to discuss an issue about the origin of variation and new traits (Figure 1). In total there are 29 students divided into seven groups that are videotaped. The teacher asks them to discuss one alternative at a time and if possible come to an agreement. When performing this group discussion the students went to another room, turned on the video camera, discussed, turned the camera off and went to the next task.

Students’ use of arguments are being analysed with the help of Toulmin’s argumentation pattern, TAP (Toulmin, 1958/2003), which is summarised below in Figure 2.

Data

Warrant

Backing

Claim

Rebuttal

During evolution living organisms have evolved a lot of different traits. The origin of this enormous variation is:

- The individual’s need of the trait
- Random changes in the gene pool
- The species strive to develop
- Need of great variation in order to get balance in nature

Students’ utterances show a great variety of how they articulate and argue on different conceptual issues. The most frequently discussed issue is whether variation originates from individual needs or from random changes in the gene pool. In order to exemplify the data and analysis (see next page) one short excerpt from a discussion between four students is shown below. In line 114 one student brings up a new example in the discussion; circumcision among Muslims. This is partly done as a reply to an earlier claim by student D that random change is unlikely, articulated as:

... if it now is that it originated randomly how come that every animal on the bloody earth has succeeded adapting to its environment.
In between these utterances above student D put forward two counter arguments. First in line 119:

and … it is nothing you need consequently it doesn't develop at all /.../ because it isn't necessary they don't need it in order to survive and then in line 121: … they don't have to do this it has to do with religion.

**Conclusion and implications**

The argumentation that student D put forward is an attempt to give more arguments that support the need-rationale, which has strong potential as an explanation among students (Southerland, Abrams, Cummins & Anselmo, 2001). When warrants are scrutinised Toulmin's element backing could be applied, although it has to be used with caution, since it often involves interpretation of implicit assumptions. In this case the utterance in line 119 … they don't need it in order to survive could be seen as drawing on a connection between need and survival; only the needs that are essential for survival are important. Making this remark student D also states a rebuttal, as he points at limitations of where need is applicable.

Furthermore it seems that student D rejects the circumcision example because it has to do with religion, meaning cultural evolution and not biological. The argument interposed by C, in turn 122 … his genes don't change just because he himself gets white is a kind of helping argument. The interpretation of this remark is that it draws on a refusal of the notion that “acquired traits are inherited”. Since this idea is common among students (Jensen & Finley, 1995) the actively articulated refusal is an important utterance.

Many of the disagreements could be traced to putting randomness or need in the foreground when explaining the origin of variation. Partly this is inherent in how the theory of evolution is understood; as one single process or two different processes. For instance it is possible that student D perceives that randomness is the one and only process that is involved in evolution. This insight could be used by the teacher in her/his assessment for learning, e.g. dividing the explanation into one part that is random, the origin of variation and one part that is not random, the selection part.

Students’ own wording is accurate most of the time, for example the utterance which settle one group’s arguing on the issue of randomness/need … random changes have occurred, just as it says, but they remained because they were needed. Students’ utterances are potential tools for teachers’ own “argumentation” that may have more impact, i.e. a language that would touch and influence students more directly without devaluing the scientific clarity and stringency.

**References**


Background, aims and framework
A range of studies indicates that teachers to a high degree make use of the textbook in their planning and teaching (Nelson, 2006), even in a time where other sources of information are easily available. Hence the textbook is essential in how the nature of a subject is communicated to learners. Textbooks are not merely simplified versions of academic literature in the field, but a re-contextualisation of this knowledge according to the organising principles, prevailing conventions and legitimate ideologies of the school subject (Dimopoulos, Koulaidis & Sklaveniti, 2003). Since physics textbooks are multimodal texts, visual images play a key role in this re-contextualization together with graphs, formulas and the verbal text (Lemke, 1998).

This paper focuses on visual images in Norwegian physics textbooks during a period of six decades. It investigates the various ways in which the images communicate the nature of physics in interplay with other forms of representations, and to what factors the variation can be ascribed.

The research questions are:
• In what ways do visual images in Norwegian physics textbooks communicate the nature of the subject?
• To what degree can variation in the use of images be ascribed to specific time periods, specific authors and school level?

The analysis of images has made use of a conceptual framework from Dimopoulos et al. (2003). Building on the work of Bernstein, Halliday, Kress and van Leeuwen, they provide three dimensions for analysis of visual images:
• Degree of content specialisation (classification); entailing types and function of the image. Types are classified as realistic, hybrids and conventional with increasing use of physics conventions. Functions of images are classified as narrative, classificational, analytical and metaphorical.
• Strength of framing; (negative) degree of involvement of the reader in the social-pedagogical relationship constituted by the image.
• Degree of formality; the degree of abstraction in the image.

The concepts this framework provides are used in constructing the typology of images in the physics textbooks.

Methods and sample
The sample consists of nine physics textbooks used in Norwegian lower and upper secondary schools from 1943 till the present. In two cases two editions of the same textbook were chosen in order to trace changes over time. In addition, two of the books are written by the same authors.

Analysis was undertaken by first categorizing individual images in terms of the dimensions presented. Secondly, five modes of images were constructed based on the categorizations and the images’ function in the text as a whole. Finally, images in the textbooks were coded in terms of these modes, and the relative presence of modes was calculated for each textbook.

The analysis concentrated on the parts of the books dealing with electricity and magnetism, in order to avoid effects of changes in the curriculum’s prescriptions of topics during the time period chosen.

Results
From the analysis, five main modes of communicating the nature of physics were identified in the visual images:

1. Involving the learner in experiments
These images are characterised by being realistic with weak framing, high content specialisation but low formality. The image together with the verbal text presents how a specific experiment is undertaken, and what will happen. The result of the experiment is then used for introduction and discussion of physics concepts or relationships. The subject matter, rather than the experiment itself, often appears as the main aim of the sequence. Nevertheless the text gives the reader the sense of participating in an experimental activity and this way strongly communicates experiments as an important basis for the development of knowledge in physics.
2. Visualising a world of models
A great deal of images in physics textbooks illustrate theoretical models of physical phenomena by visual means. They may be seemingly realistic, but represent conventions in how the world is perceived in physics. Their function is analytical or in some cases classification. This mode of representing physics also includes images that portray generalized ‘inscriptions’ (Latour & Woolgar, 1979) of the world in terms of graphs or diagrams, describing physics phenomena as consistent mathematical patterns.

These two types of images have in common that they demonstrate to the learner that physics is about representing the world in a different way than how it is usually perceived, i.e. by the use of models, and that learning physics means to learn to see the world this way.

3. Showing the actual appearance of objects
This mode of imaging in physics textbooks presents the actual appearance of objects. It embraces realistic images of objects in themselves, free of contexts such as experiments or otherwise. The purpose is to familiarize the learner with specific objects important in physics.

4. Translating between representations
A hybrid of the conventional and realistic images in modes 2 and 3 gives rise to a specific mode of visualisation, creating links between the actual appearance of objects or systems and how features of these are represented in the models used in physics. The role of the image in the text is hence to perform a translation between the two ways of representing the world.

5. Demonstrating relevance and use
These images demonstrate for the learner how the subject matter presented has relevance and is used in society and daily life by presenting objects and systems well known to the learner. They contribute to a reduction in formality and weakening of framing in the text as a whole, but are often independent of the flow of other text.

The typology presented above is used in the final phase of analysis, where each textbook is analysed with respect to possible patterns in modes of imaging. In comparing the results for individual textbooks, some changes over the time span analyzed could be identified, especially with regards to increasing formality in the images. We also see a move from realistic to conventional images, involving a strengthening of the framing, i.e. less involvement of the learner.

With the exception of mathematical formalism, there appear to be no important differences between how images appear in textbooks for levels corresponding to lower and upper secondary school. Identical images were frequently found in books intended for different levels. Reforms in the formal curricula also seem to have had little influence on the kind of images used.

The strongest pattern is found in differences between specific textbooks; they seem to adopt certain modes of visualizing physics, to such a degree that it can be seen as forming specific genres. For example, in one textbook widely used during several decades until the early 1970s, more than half of the images are classified as Involving the learner in experiments, consistently used to introduce new concepts and relationships, and hence highlighting experiments as a basis for knowledge in physics. One of the two leading textbooks used today is dominated by images of the mode Translating between representations, while the other tend to use images as a tool for Visualizing the models of physics. Both books have fewer images of the modes Involving the learner in experiments and Showing the actual appearance of objects than older textbooks, but tend to present more images in the Demonstrating relevance and use mode. Involvement of the learner in the physics presented in textbooks thus seems to have shifted from involvement in experiments to involvement in the sense of recognising physics in everyday surroundings.

It seems reasonable to ascribe the variation between individual textbooks to the preferences of individual authors. However, it was also found that authors of books for different types and levels of schools showed major variation in the pattern of images in their textbooks. Hence authors, or publishers, seem to develop and pursue a specific pattern for each book.

Conclusions and implications
This study has identified a variety of modes of how images in physics textbooks present the subject. Awareness of this variety is important for teachers as well as textbook writers. The increasing formality and the move that has been observed from realistic images and experiments to images that require familiarity with conventions of science is a matter of particular concern. This development may reinforce ‘cascades of inscriptions’ (Roth, Tobin & Shaw, 1997), where the transitions between representations are not transparent to physics newcomers.
A new approach to analysing student argumentation
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Background, aims and framework
The importance of argumentation in science teaching has been stressed by many scholars (Duschl & Osborne, 2002), and there is a growing body of studies focusing on argumentation. So far, a main focus of research on argumentation and controversial issues in science education has been on the process of argument rather than its content, e.g. evaluation of the students skills in constructing arguments and how students form opinions concerning controversial issues (Erduran, Simon & Osborne, 2004). This study aims at doing both: a new approach to analyzing arguments is developed, consisting of an extended version of Mercer’s (1995) way of categorizing talk in small group discussions, combined with a tool for evaluating content of arguments.

The new approach is applied on empirical data from biology role-play debates, to answer the following research questions:

• What is the structure of student argumentation?
• What is the content of student argumentation?
• How does structure relate to content in student argumentation?

Methods and sample
The empirical part of this study is from a context of role-play debates preceded by work in the interactive learning environment Wolves in Norway at viten.no. Wolves in Norway consists of six web-based units and an off-line role-play debate.

Participants were a class of 23 Norwegian students age 14-15. The teacher was the author of this paper. All students worked in pairs, spending four lessons on the web-based activities and two lessons preparing and performing the offline role-play debates. The debates were video recorded and later transcribed.

The structure of student utterances in the debates were analysed according to an expanded version of Mercer’s (1995) categories for small group discussion (Table 1).

Table 1 Overview of types of talk and the features of each type, based on Mercer (1995). N-students represent nature protection organizations; F-students represent farmer and hunter organizations.

<table>
<thead>
<tr>
<th>Types of talk</th>
<th>Features of talk</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disputational</td>
<td>Claim</td>
<td>Example 1:</td>
</tr>
<tr>
<td></td>
<td>Counterclaim</td>
<td>Student N2: “Actually, as it is nowadays, humans kill more wolves than wolves kill humans.”</td>
</tr>
<tr>
<td></td>
<td>Challenging question</td>
<td>Student F2: “Yes, but it isn’t humans that are threatened by wolves. It is...”</td>
</tr>
<tr>
<td></td>
<td>Avoids answering question*</td>
<td></td>
</tr>
<tr>
<td>Reasoned</td>
<td>Claim with reason*</td>
<td>Example 2:</td>
</tr>
<tr>
<td>disputational*</td>
<td>Counterclaim with reason*</td>
<td>Student N4: “They don’t live in captivity, they live on 300 km”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student F1: “Yes, but they are wandering animals, you said it yourself... They like to wander. It (to be caught) is against their nature”</td>
</tr>
</tbody>
</table>
Cumulative | Repeat | Confirm | Elaborate | Example 3:  
**Student N4:** “You don’t have a relationship to your animals if you release them out in the woods and just let them go there on their own. Either you must look after your livestock, or you must find yourself something else to do!”  
**Teacher:** Comment from student N1 (asks for permission to speak)?  
**Student N1:** “Yes, when you let your animals out in the nature there will certainly be predators there, and you must take the consequences of that!”  
**Teacher:** Student N3 (asks for permission to speak)?  
**Student N3:** “Yes, I was going to say the same thing.”

Exploratory | Explain | Reason | Offer alternative solution | Example 4:  
**Teacher:** “Audience?”  
**Student in the audience:** “Yes, the so called wolf zones, I think they will fail. Because it is a fact that wolves wander, and then they will wander to the old places wouldn’t they? But of course, they have territories, I know that, but then there are these “vagabond” wolves that part from the flock and wander freely. Then it creates a family with another wolf that it meets you know? And then you have another flock. And this is not in the same territory and not in the wolf zone. It can move to another place can’t it?”

*Reasoned disputational talk and features in bold are added by the author.

The content of student utterances was categorized according to the extent to which they were able to draw on information from *Wolves in Norway*, or other sources, and use it correctly. The following hierarchy of categories was used: expected-, moderate-, incorrect- and other content (Table 2).

<table>
<thead>
<tr>
<th>Types of content</th>
<th>Features of content</th>
<th>Examples</th>
<th>Commentary</th>
</tr>
</thead>
</table>
| Other | -Trivial content  
-Content on the edges of the original theme  
-Non-finished sentences  
-No particular content. | Example 1  
“Yes, how long is it since the last time you ate meat, student N1?” | Illustrates a type of utterance that is classified as out of context, because it is not focused on the original theme. |
| Incorrect | -Incorrect use of information from the program  
-Brings in incorrect additional information. | Example 2  
“But wolves haven’t killed humans.” | Not consistent with the information provided in the *Wolves in Norway*. Wolves actually have killed humans; both in Norway (200 years ago) and other countries; however, it usually happens only under specific circumstances. |
| Moderate | -Partly correct, but inaccurate use of information from the program.  
-Brings in partly correct additional information. | Example 3  
“Yes, of course, but the fact is that we are getting very small amounts of money from the government… for support. So we cannot afford to do something else. We cannot afford paying wages to shepherds and things like that. So that is the only solution if the animals are going to graze.” | Brings in additional information, which is partly correct, i.e. using shepherds is not the only solution to the problem (alternatives are described in *Wolves in Norway*); and the government might give additional support if farmers test new methods, like using special Polish shepherd dogs. |

Table 2 Categories for classifying quality of content in student utterances. N-Students represent Nature protection organizations, F-students represent farmer and hunter organizations.
The content of student utterances was further investigated by analysing the types of arguments that were used in the debates (Table 3).

**Table 3** Classification scheme for types of arguments in student utterances, and numbers of arguments introduced in Wolves in Norway, and arguments introduced in the debates by students.

<table>
<thead>
<tr>
<th>Type of argument</th>
<th>Characteristics of argument</th>
<th>Arguments introduced in Wolves in Norway (arguments introduced by students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td>Those based on biological knowledge about the behaviour and ecology of wolves and other predators, and their influence on other species.</td>
<td>11 (4)</td>
</tr>
<tr>
<td>Economic</td>
<td>Those involving economic gains or losses due to wolves.</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Personal</td>
<td>Those connected to feelings such as fear. Those connected to protection of ones person and livestock. Those giving wolves a non-economical value for people.</td>
<td>5 (4)</td>
</tr>
<tr>
<td>Political</td>
<td>Those connected to laws and international agreements, as well as to consequences of the laws and agreements, i.e. management of wolves.</td>
<td>4 (0)</td>
</tr>
<tr>
<td>Comments</td>
<td>Commenting on other arguments, clarifying questions or similar.</td>
<td></td>
</tr>
</tbody>
</table>

**Results**

Figure 1 visualizes a profile of the discourse in the debates, by showing how the correctness of content in student arguments corresponds to the structure in terms of different types of talk.

**Figure 1** Structure and type of content in student utterances. N=119 student utterances.
Figure 2 illustrates the proportion of the various types of arguments used by the students, combined with the degree of correctness of each type.

Figure 2  Types of arguments used in the three debates, and the degree of correctness of each type. 140 arguments are included.

Conclusions and implications
The main contribution of this paper is a methodological approach for analyzing student argumentation in terms of both content and structure. This approach illustrates the correctness of content in different types of talk. Both simple claims and more elaborated argumentation contained correct content. The content analysis showed that the majority of content in student utterances was correct or partly correct, indicating learning gains. Students used biological, personal, political and economic argumentation reflecting the sense of having access to a tool providing information from multiple sources. Furthermore, exploratory talk seems to be associated with correct content.

This study also demonstrates that the new approach to analysing argumentation can be used to analyse all discourse in teaching sequences like debates and discussions. In contrast to other approaches where just selected sequences are analysed, the new approach provides an important overview of what types of talk are used in the whole discourse. Furthermore, whether or not the utterances consist of correct subject content, and what type of subject content that is used. Such information is useful for teachers and science educators in evaluating whether students are able to apply subject content knowledge in settings like debate or discussion. Moreover, the new approach is a tool that may help us considering whether or not to teach explicitly about the construction of arguments and to which extent the teaching aims regarding subject content are reached.

References


Argumentation om materiens förändring vid smältning
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Bakgrund, syfte och teoretisk ram
Brittiska studier (Driver, 2000; Newton, 1999) visade bl.a. att diskussioner och argumentationer utgjorde en försvinnande liten andel av undervisningen i naturvetenskap och att lärarna ansåg att det är svårt att leda diskussioner. Dels beror detta på att lärarna inte ansåg sig ha tillräcklig erfarenhet av och kunnande i detta, dels på den kunskaps- och vetenskapssyn lärare i naturvetenskap ofta omfattar.

Toulmin’s argument pattern (TAP) (Toulmin, 2003) har använts och utvecklats i flera studier i syfte att studera elevers argumentation och hur den utvecklas. Det är dock sällsynt med redovisningar av detaljer i argumentationerna och hur dessa är uppbyggda. Syftet är att detaljerat beskriva hur elevernas argument är uppbyggda för att bättre förstå förutsättningar för lärande i gruppdiskussioner.

**Metoder och urval**

Data har samlats in under en undervisningssekvens inom området ”fast-flytande-gas”. Läraren och hennes elever arbetar med en frågeställning som ingår i ett undervisningsmaterial som producerats med syfte att lyfta fram och bearbeta elevers idéer om naturvetenskapliga fenomen (Andersson, Bach, Hagman, Olander & Wällin, 2005; Bach & Wällin, 2006; Black et al, 2003).

Problemet som eleverna diskuterar är hämtat från den Nationella utvärderingen av grundskolan 2003, ”Bevaras massan då is smälter” (Andersson, Bach, Olander & Zetterqvist, 2005, p. 66). Uppgiften handlar om huruvida massan förändras så att en slutna burk med is kommer att väga mer, mindre eller oförändrat efter att isen har smält.

Frågeställningen behandlades först i grupper om tre eller fyra elever som en av flera uppgifter. En av grupperna filmades. Dagen efter följdes gruppernas bearbetning upp med en diskussion mellan läraren och elever från flera grupper i halvklass. Lektionen filmades.


**Resultat**

Analys av samtalen som rörde uppgiften under de två lektionerna gav tre tydliga ”Patterns of Argumentation”. Tidigt framkom ett mönster med utgångspunkt i att is är lättare än vatten varför burken bör väga mer efter smältning.

D (Is är lättare än vatten)  ➔  So Q (tror att/ borde bli så att)  ➔  C (Burken väger mer än 630 gram när isen har smält)

Since W (Is flyter på vatten)

Under lektion två, när halva klassen diskuterade problemet tillsammans, bad läraren att de olika grupperna skulle presentera sina resonemang. Då framträdde två andra ”patterns of argumentation”. Det ena gick ut på att eftersom is är hårdare och tar mer plats bör burken bli lättare efter att isen har smält.

Figur 1  Toulmin Argument Pattern

Figur 2  Burken bör väga mer efter att isen har smält.
Eleverna som framförde ståndpunkter enligt det tredje mönstret menade att burken har ett lock och att därmed inget har tillfösts eller lämnat burken, varför den borde väga lika mycket hela tiden.

Diskussionen gick vidare och några av eleverna med utgångspunkten att burken blir lättare efter att isen har smält fördjupade sitt argument med ett 'backing', nämligen att övriga måste hålla med om att gas är lättare än flytande och att därmed borde flytande vara lättare än fast.

Framförallt en pojke stod fast vid att burken väger mer efter att isen har smält. Argumentet att gaser är lättare än flytande stärkte hans ståndpunkt att burken kommer att väga mer. Is flyter på vatten och gaser svävar i luften – således är vatten tyngst, is lättare och vattenånga lättast, vilket innebär att burken väger mer efter att isen har smält.

**Figur 3** Burken bör väga mindre efter att isen har smält.

**Figur 4** Burken bör väga lika mycket efter att isen har smält.

**Figur 6** Utvecklad argumentation om varför burken blir lättare efter isen har smält.

**Figur 7** Fördjupat argument varför burken blir tyngre efter att isen har smält.
Diskussionen gick fram och tillbaka mellan eleverna och läraren gick också in i diskussionen och ställde frågor om materiemängd före och efter smältning. Det visade sig då att eleverna var överens om att mängden materia är lika före och efter smältning. Läraren menade då att saken var klar, vitken ändras inte. En av eleverna gav sig dock inte utan hävdade bestämt att det inte betyder att vitken är densamma.

**Slutsatser och implikationer**

Analysen m.h.a. TAP visar att elevernas olika resonemang var och ett på sitt sätt är logiskt uppbyggda med en struktur som går att beskriva. Eleverna upp fattar, utgående från samma problemställning, olika fakatillstånd, framför skilda skäl med belägg för hur fakatillståndet hänger samman med deras eget påstående. Sammantaget pekar de olika TAP på att eleverna har olika föreställningar om vad som händer med vitken vid materiotransformationer.


Ett annat skäl kan vara att en del av det som karaktäriserar Exploratory Talk (Mercer et al., 2004) saknas. Elevernas uttalanden blev aldrig resurser för vidare resonemang, man lyckades inte överbrinna avståndet mellan de olika föreställningarna.

**References**


Learning science with ICT
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Meyvant Pórolfsson
Allyson Macdonald

Background, aims and framework
Background
A new national curriculum for Icelandic schools was published in 1999. Both the science and the information and
technology education curricula from 1999 made considerable demands on teachers. Science was to be taught through three themes – the nature and function of science, science content (physical, life and earth sciences), and methods and skills. Information and technology education was divided into three subject areas – information studies, creativity and the practical use of knowledge, and design and technology. In addition, guidelines were provided for the development of computer skills.

A recent study in Iceland drew some general conclusions about the kinds of support and structure teachers seem to need in order to make the use of ICT a real option in their teaching (Lárusson, Macdonald & Þórólfsson, 2005). Technical difficulties can hinder the use of ICT in subject-based classes and many teachers need support from teaching advisers, library specialists or computer specialists in order to use ICT in their classroom teaching. Other research indicates that teachers do not adopt ICT unless its use is aligned with their usual teaching practice and that this practice is largely teacher-centred (La Velle, McFarlane & Brawn, 2003). In a study of 25 technology-rich classrooms in five European countries, Smeets and Mooij (2001) drew essentially the same conclusion; that despite more pupil-centred environments, teachers tend to stay firmly in control of them. Osborne and Hennessy (2003) suggest that part of the difficulty with using ICT seems to lie with a national curriculum loaded with science content although new curricula are more likely to encourage the use of ICT with an emphasis on critical and analytical skills (Osborne & Hennessy, 2003).

Aims
During 2005 research was carried out with five science teachers in the urban southwest area of Iceland with support from the IUE Research Fund. The study was designed to:
• consider the conceptions of teaching and learning held by these teachers
• assess the extent and manner in which ICT was used by them in their science teaching.

In the first part the authors found that all five teachers experienced the pressure for coverage as a constraint and they were well aware of their students’ different needs and diverse learning styles (Pórolfsson, Macdonald & Lárusson, 2007). The teachers talked about taking the differences of students into account and admitted that the learning context is a crucial factor for learning. They suggested that the system assumes that teaching science is still mostly about transmission of knowledge and the transfer of information from books and other sources of information into student’s minds.

The aim of this paper is to report on the second part of the study i.e. to assess the way in which the five teachers were using ICT in their science teaching.

Framework
Research suggests that ICT can be used to strengthen procedural knowledge and that the main forms of ICT which are relevant to school science activity include: tools for data capture, processing and interpretation, multimedia software, information systems, publishing and presentation tools and computer projection technology (La Velle, McFarlane & Brawn, 2003; Osborne & Hennessy, 2003). Using ICT for such purposes calls for a particular view of school science. ICT could reduce both the time and resources constraints in practical work. There is however a need for a learning context in which exploration and testing can occur, for example, simulation and digitally presented data sets, such that students can learn more about the underlying scientific processes.

Newton and Rogers (2003) suggest that ICT tools add value to science lessons in two ways; through the intrinsic properties of ICT, such as time saving or handling data, and through potential learning benefits from the manner in which ICT is used in the classroom. They make a distinction between properties and benefits. Operational skills are needed to exploit the properties of ICT but application skills are needed to exploit the benefits.

Newton and Rogers suggest that use of ICT can be related to pupil-learning modes suggested by Scrimshaw (in Newton and Rogers, 2003) which are in line with constructivist ideas of teaching and learning science. As receivers learners can obtain knowledge or collate and record information. As explorers they explore ideas and external knowledge. As creators they present, report and create their own understandings. To Scrimshaw’s roles they add that of reviser where students engage in revision activities or practice activities.
Twining (2002) developed the Computer Practice Framework (CPF) with which it is possible to differentiate ways in which computers are used in teaching situations. The question “For what purpose?” concerns the extent to which the use of the technology is affecting the content and practices of learning. Twining has identified three categories:

- ICT used as support (same content, automated process but essentially unchanged; could be more efficient but does not change the content)
- ICT used for extension (different content and process but neither requires a computer)
- ICT used for transformation (different content or process, both requiring a computer such that either the content or process changes).

In summary, the literature indicates that for effective use of ICT in science the following factors will be important:

- ICT is usually used in alignment with existing pedagogical practice,
- ICT can be used to support the development of procedural knowledge, and
- Teachers need technical and advisory support for using ICT in science teaching.

Furthermore, teachers could find it useful:

- to differentiate between the properties and the benefits of ICT
- to consider the different roles which learners must assume such as revisers, receivers, explorers or creators of knowledge
- to realize that ICT can be used to support, extend or transform learning.

**Methods and samples**

During 2005 the research team carried out a study on the use of ICT in science teaching, with funding from the IUE Research Fund. Five teachers, three male and two female, participated in the study and were all from the urban southwest. A snowball sample was used in identifying the first three teachers as being “good” science teachers. The other two were known to the researchers as innovative teachers of science. Four teachers were teaching at lower secondary level, and one at middle school level.

Semi-structured interviews lasting about 60 minutes were taken with five teachers in their classrooms, followed later by an observation of a lesson selected by the teacher as being a typical lesson. The interviews focused primarily on the ideas teachers had about learning and teaching in science and their typical practice. The interviews were then transcribed for further analysis. During the observations attention was paid to nature and content of the interactions between teacher and learners. The observation was followed by a short interview to clarify points arising from the earlier interview and the observation.

**Results**

It appears that the use of ICT by science teachers seemed to be consistent with their ideas about teaching and learning science.

Three of the teachers favoured a student-centred approach to science learning, one a mixed methods approach and one a teacher-centred approach. The way in which ICT was being used is aligned with these approaches. Those who favour a student-centred approach would like to encourage a range of skills; and would like to use ICT in all areas of learning. Simon uses digital film clips to tape presentations for later evaluation and interacts informally with students. Smart board and slide presentations are used by students during presentations. Jacob emphasises discussion periods and allows students good access to him, between lessons and through MSN after school. There is a relaxed atmosphere in the lesson and students are encouraged to use the web to look for information. Olive likes to use a variety of teaching methods, to meet different interests and needs, and prefers to follow the national curriculum rather than books. She uses the computer and the Internet much of the time and students use the Internet, spreadsheets, slide presentations and word processors.

Saga, who adopts a mixed approach, values traditional investigations and is guided by the textbook. She seldom uses demonstrations and follows the curriculum closely. She feels she is not strong in ICT but would like to be stronger. She is reluctant to direct students towards web-based information because so much of it is in English. Students take notes from powerpoint presentations.

Peter who adopts a teacher-centred approach favours direct teaching, built on the text, notes and key concepts. He values a structured approach and uses demonstrations in place of students doing practical work.

**Conclusions and implications**

The teacher who used ICT the most in science had a strong student-centred approach but also had a strong background in ICT itself. Few of the teachers seemed to use ICT in order to transform learning (cf. Twining, 2002) but some used ICT to support or extend learning.
There is little evidence of ICT being used to develop procedural knowledge in science as suggested by La Velle et al. (2003). Indeed the first results from these five teachers do not indicate the presence of a strong science culture – for example, Simon and Peter appeared to be very different in their approach to the subject of school science.

Follow-up work is needed to look more closely at the conditions which seem to favour the use of ICT in science teaching and learning in Icelandic schools by studying teachers who are known to use ICT in learning and to understand critical points in their personal history of science teaching.

References


A qualitative exploration of teachers use of ‘digital creativity’ technology to re-engage detached learners

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Background, aims and framework
The term ‘digital creativity’ commonly refers to the interface between digital technologies and the ‘creative arts’. This paper takes a broader definition: ‘the imaginative application of computer hardware and software to support learning and learning design across the school curriculum’. The focus of our report is that sub-set of qualitative data from our Becta (British Educational and Communications Technology Agency) funded research that reveals interesting potential in the domain of science education. Following informal research enquiries, this one-year project provided more systematic evidence on the impact of ‘digital creativity’ on pupils’ behaviour, attitude, learning and attendance and on school and teacher practices in using digital resources creatively (Russell & McGuigan, 2008). The target pupils were designated as having ‘behavioural, emotional and social difficulties’ – BESD being a classification indicating additional educational need and defining those young people potentially most disengaged from formal education. Information was gathered from learners posing severe teaching and learning challenges to teachers and education systems, though the issues they raise are of equal relevance to mainstream education. The increasing prevalence of 24/7 multimedia ICT functionality requires that urgent attention be paid to the challenges and opportunities afforded by these resources to the development of engaging science education, the more so in the context of pupils’ declining uptake of science subjects. Some wider implications for planning learning design and assessment in science teaching and learning are also suggested.

Methods and samples
Ten schools distributed across England (five residential, all specialising in the education of BESD pupils) participated in the study between June 2006 and July 2007. One link person was identified in each school which received a donation of hardware and software on the understanding that information about usage and impact would be systematically recorded. Hardware was a MacBook Z0D5 Notebook plus a 30GB iPod, Music keyboard, Canon video camera and still cameras. Software comprised the Apple iLife suite (iMovie, iDVD, Photo Booth, GarageBand, iPhoto, iChat, iWeb, Podcaster) supplemented by ‘ComicLife’ (a picture strip page layout facility) and ‘I Can Animate’ stop-frame animation software plus a ‘Mac’ account. None of the schools had outstanding prior ICT expertise.

A qualitative ‘development and research’ approach was adopted (van den Akker, 1999). Project innovations were fed back to teachers immediately, in contrast to the more typical ‘arm’s length’ approach. Video-recorded exemplification of prior expertise in digital creativity, developed in a school having exemplary practice, was made available to the school sample.

Project data collection used two group meetings, an on-line forum, email and telephone. Teachers maintained records of the frequency and nature of use of the project’s digital resources and pupils’ views of the impacts. Questionnaires were distributed and structured interviews recorded, supplemented by field notes from school visits. All project forum
communications were recorded and classified. The researchers collected multi-media recordings which were transcribed, edited, and interpreted using systematic qualitative methods including diagnostic commentaries.

**Results**

The evidence confirmed that exposure to ‘digital creativity’ resulted in:

- some radically innovative teaching strategies that enthused teachers and extended their habitual instructional repertoire
- compelling examples of unprecedented levels of learner motivation and enjoyment, including prolonged engagement of pupils with attention deficit hyperactivity disorder (ADHD) and autistic spectrum disorders (ASD). Pupils’ pride in the professional appearance of their multimedia products was striking. Examples of pupils’ science work have been edited for dissemination, to illustrate to the teaching profession the potential of digital creativity in science education.

*Example 1.* Learners carried out science investigations which they recorded in picture-strip form, using digital still cameras to photograph the processes and one another as they conducted investigations into dissolving. They stored their images using iPhoto, used ComicLife software to construct picture frames, titles, speech bubbles and text boxes, keying in text to add their commentaries, with thought bubbles adding humour and metacognitive commentary.

*Example 2.* Pupils used digital cameras to record their experiences during a visit to a science interactive centre, photographing themselves and their peers as they interacted with the geological exhibits on display, reviewing their record of the experience on return to school.

*Example 3.* Some younger children made animations on the subject of safety. They constructed sets and models and story-boarded the plots before using stop-motion animation software to produce sound and motion morality tales addressing safety issues.

Some educationally important characteristics of digital creativity are:

- multiple modes of expression are appreciated by pupils, both intrinsically and because they offer alternatives to verbal means: less articulate pupils found new ways to express themselves
- access to multimedia was found to be enjoyable, engaging and motivating as a means of achieving success, resulting in enhanced attention span and productivity
- the hardware and software offered a strong link between pupils’ life-worlds and the agendas of the institutions they attended, offering ‘street credibility’ to learning
- multimedia constructions could be highly personalised - personal ownership linked personal values with the educational goals of the institution
- digital products offered pupils convenient and portable means of sharing and storing records of their knowledge and achievements e.g. to add to their e-portfolios
- learners’ development of software expertise – often overtaking their teachers’ – facilitated personal control of and re-engagement with educational goals
- many digital creativity activities required or encouraged collaboration, positive interpersonal behavior and consensus
- products having a professional appearance were rapidly produced by inexpert users, resulting in enhanced pride and self-esteem
- software integration - the movement of files between applications - was found trouble-free and user-friendly by novice users.

**Conclusions and implications**

**Theoretical**

Gibson’s ecological theory of perception (Gibson, 1979) assumes that human perception has a functional relation with the environment, the possibilities for action being ‘affordances’. Gibson’s theory invites the question, ‘What novel affordances arise from digital creativity resources?’ Our research has identified some novel possibilities for meaning-making in the relations between the equipment provided and users. The pedagogical consequences of digital resources are not intrinsic to those resources; they have to be analysed and understood by educators in order to be applied effectively. Multimedia functionality offers scope to express ideas in a range of representational forms, and the disciplines of both rhetoric and semiotics are likely to provide yet further insights. Wertsch’s (1995) concept of ‘cultural tools’ offers a useful sociological interpretation of ‘digital creativity’: the resources did not just facilitate what might have occurred anyway. New cultural tools give rise to novel behaviours and outcomes and may be empowering. One striking example of enhanced autonomy was the increase in the control handed over to learners. For example, acknowledging the facility with which pupils learned to operate new software, some teachers were willing to accept pupils playing an active role in training not only their peers, but also members of staff and other adults.
Practical
Project teachers were unanimous that an important, exciting and innovative educational resource had been made available to them. The impact on ‘intermediate outcomes’ – motivation, perseverance, collaboration and reflection, were strongly confirmed. Novel multimedia affordances were an undoubted factor in teacher success in adopting innovative procedures. The intention is that the project’s multimedia evidence will be used to make pedagogic strategies known more widely to meet a diverse range of pupil needs, both BESD and mainstream.

The limitations of written modes of knowledge communication have been commented upon (Lemke, 2003); some researchers are currently focused on understanding visual representations as used in textbooks (Knain & Hugo, 2007; Roth, Pozzer-Ardenghi & Han, 2005). The implications of multimodal knowledge representation in science education has been the focus of some attention (Kress, Jewitt, Ogborn & Tsatsarelis, 2001). Our research suggests this area remains fertile for further research activity, both theoretical and for practice.

An immediate need is to consider the possibilities and constraints for learning design and for assessment. For computer-mediated assessment, there are implications for the design of information presentation modes and learner response modes. Currently implicit, but likely to become more pressing as school information management systems develop, are the challenges in managing and storing learner multimedia expressions of their assessed understanding e.g. using learning platforms, e-portfolios and virtual repositories.

References
Planning science instruction: From insight to learning to pedagogical practices

Proceedings of the 9th Nordic Research Symposium on Science Education
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Synopses: Resources for learning science outside schools

December 2008
Resources for learning science outside schools

When the teacher takes the school out of the school: an analysis with focus on the role of the teacher when visiting nature centres and other out-of-school places
*Trine Hyllested*

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Resources for learning science outside schools
When the teacher takes the school out of the school: an analysis with focus on the role of the teacher when visiting nature centres and other out-of-school places

Trine Hyllested th@holsem.dk

Theoretical background and purpose
This study investigates the use of out-of-school activities in science in Denmark. The use of out-of-school activities is one of many ways of enhancing interest in science and is recommended by the Danish Ministry of Education. Some research in out-of-school activities in Denmark has been published. This empirical work investigates the out-of-school activity from the perspective of the teacher, building on the work of Griffin (1998a, 1998b, 1998c, 2004), Kiesel (2003, 2005) and Storksdierk (2002, 2004) among others.

The out-of-school centres represent a new expertise. The historical analysis of the out-of-school centres in Denmark revealed a gradual development in out-of-school activities. The professional framework for using the society outside the schools, by using guides and museum educators, has grown since the middle of the 1960s. The specialisation of the teaching in using the professional "out-of-school" facilities is an example of the creation of an expert system for the schools. One hundred years ago the teacher took the class out by herself/himself, today the teacher takes her/his class out to a professional place where an expert presents a special event for the class.

This is interpreted in relation to the theory of disembedding and expertise (Giddens, 1990, 1991). Giddens described the modernity in his book *Modernity and self-identity* (Giddens, 1991). The modernity is characterized by progressive separation of functions, such as modes of activity that become more specialised and precise with the advent of modernity. I consider the development of the professional framework for interpretation in nature centres, museums, science centres, etc. a form of disembedding.

It is a new pedagogical challenge for the teacher to deal with such a wide range of expertise. This study investigates the concept of learning in the out-of-school places in this new pedagogical situation. It builds on different theoretical aspects. First of all on the view of learning from Vygotsky, but also Piaget. The concept of learning is also related to the international literature of informal learning, particularly Hein (1998) and Falk and Dierking (2000). The purpose of this study is to investigate and discuss when the teacher takes the school out of the school. The analysis focuses on the role of the teacher when visiting nature centres and other out-of-school places.

The research questions are:
- Why do the teachers use out-of-school activities?
- How do the teachers support student learning in out-of-school activities?

The empirical work
The empirical work was conducted from three different perspectives. The first study investigated different ways of learning in one specific out-of-school setting: a nature centre. Eight visits by 100 students (7-14 years old) were observed. Direct drawings and sentences from the students on what they thought they had learnt that day were collected. Three months later semi-structured interviews with teachers and students were conducted.

The second study investigated the role of the teacher when students used an out-of-school activity as part of problem-based project work being conducted in a lower secondary school. Fourteen days of full-time science teaching were observed. Twenty-two students worked in six project groups culminating in a presentation of their study. Three teachers supervised them. The author was a pedagogical ethnographer and observed, interviewed, photographed and followed the students and the teachers. Five groups (18 students) chose to go on a visit out-of-school. Semi-structured interviews were conducted with the students and the teachers. Pre- and post-tests on the purpose of using out-of-school activity were conducted with all the students.

The third study involved action research and informed the practice of the participating teachers and the researcher. It was a one-year study of a group of six science teachers. The teachers used out-of-school activities as one of several teaching strategies in science in a lower secondary school. The author joined the group meetings both as an observer and consultant. Semi-structured interviews with the teachers were conducted. Evaluation essays on their teaching were also collected.

Results and analysis
From the interviews with the teachers in all three studies their intentions of using out-of-school activities were analysed. The analysis of the interviews in relation to learning showed different dimensions in the teachers’ learning intentions. With inspiration from the domains in Bloom’s taxonomy and with contribution from the views of Vygotsky (1978) the intentions of the teachers for the teaching were analysed into four different dimensions:
• A cognitive dimension: “I cannot full fill the curriculum without going outside school”.
• An affective dimension: “They must have this nature experience”.
• A psychomotor dimension: “They can get the opportunity to work with their hands”.
• A socio-cultural dimension: “Some students get new roles in the class, when they go out”.

The teachers often expressed more than one dimension of learning in the interviews. The three empirical studies showed that the use of out-of-school activities back in the school were related to the role the teacher adopted and the way the teacher supported the learning process.

Conclusions and implications
The purpose of the teacher and the way he or she supported the students were of utmost importance for the learning process. The way the teacher used the out-of-school activity as a learning method greatly influenced the learning process. Clear purposes, clear requirements for the students and teacher collaboration were important. The conceptual background of the teachers, their purpose for going out, their preparation and follow up on the out-of-school activity had a great impact on the learning process.

It is important to initiate and support in-service education for Danish teachers in using out-of-school activities. The teacher is a key person in providing the learning conditions for the students, but the students are the key persons in the learning process.

References

Autenticitet i undervisningen i Aalborg Zoo´s skoletjeneste
Niels Anders Illemann Petersen
Mette Dalgård Alders md@aalsem.dk

Baggrund
Autenticitet er et begreb, der betoner vigtigheden af, at undervisningen er i overensstemmelse med elevernes tankeverden, den del af omverdenen, der undervises i samt de fagligheder, der bruges i tilgængelsen af det pågældende indhold (Bangsgaard, Dolin, Rasmussen & Trinhammer, 2001).

Bangsgaard et al. (2001) beskriver tre former for autenticitet:
• Personlig autenticitet, undervisningen skal være vedkommende og meningsfuld for eleverne ved at give mening i relation til deres hverdag og tankeverden, eller fordi den indgår i en større sammenhæng.
• Samfundsmæssig autenticitet, angår samfundsmæssig relevans.
• Faglig autenticitet, undervisningen sker på en fagligt forsvarlig og realistisk måde.

På ovenstående baggrund udvælges følgende indikationer ved autentisk undervisning i Aalborg Zoo:
Personlig autenticitet
Undervisningens indhold er meningsfuld for eleven og knytter an til elevens erfaringsverden
Miljøet i Zoo er motiverende for elevernes læring
Samfundsmæssig autenticitet
Globale problemstillinger
Sammenhæng med den daglige undervisning og Undervisningsministeriets Fælles Mål\(^1\) for undervisningen i grundskolen

Fagligt autenticitet

Metodisk aspekt

Fagligt aspekt

Alternative læringsmiljøer, f.eks. skoletjenesten i Zoo, oplever, at de ikke altid er i stand til at støtte lærernes daglige praksis, så besøgene rækker ud over timerne besøget varer (Ellenbogen, 2005).

Der kan sandsynligvis skabes større sammenhæng mellem den daglige undervisning og de alternative læringsmiljøer, når læreren har kendskab til det alternative læringsmiljøs tilbud (Busch, 2004).

Ligeledes vil elevernes engagement øges, hvis læreren før, under og efter besøget arbejder med relevante temær (Busch, 2004; Ellenbogen, 2005). Oplevelsesprægede aktiviteter i det alternative læringsmiljø kan herved blive 'fyrtårne i erindringen', og være udgangspunkt for dybere faglig forståelse i den daglige undervisning (Busch, 2004).

Mål

Formålet med projektet "alternative læringsmiljøer", under CAND\(^2\), er at optimere samarbejdet mellem skolen og de alternative, naturfaglige læringsmiljøer. Et delprojekt er, i et samarbejde mellem Zoo og UC Nordjylland, at udvikle samarbejdet mellem skole og Zoo’s skoletjeneste. Målet er at opnå større sammenhæng mellem læring i skolen og Zoo, så elevernes læringsmæssige udbytte øges.

Vi antager, at autentisk undervisning er en del af det, som karakteriserer skoletjenesten i Zoo’s arbejde. I dette delprojekt er formålet at undersøge autenticitet i undervisningen med henblik på at udvikle et Zoo-kursus for naturfagslærere.

Metode

Data er indsamlet gennem observation af undervisningsforløb med 4 skoleklasser i Zoo, samt interviews af elever og lærere. Analysen af resultaterne fra de fire klasser er færdige i foråret 2008, derfor har vi i denne publikation valgt at arbejde med resultaterne fra en enkelt klasse, 20 elever på 15-16 år fra Vittrup Efterskole.

I denne publikation er den faglige autenticitet udeladt af pladsmæssige årsager. Der er fokus på den personlige og den samfundsmæssige autenticitet, ved følgende indikationer:

Personlig autenticitet:

- Eleverne er opmærksomme, koncentrerede, stiller spørgsmål, er aktive i undersøgelser
- Eleverne syntes de lærer noget vigtigt, de har lyst til at komme igen
- Lokalet er interessant, og indeholder materialer de kunne tænke sig at undersøge nærmere
- Undervisningen i Zoo er anderledes end undervisningen til daglig i skolen.

Samfundsmæssig autenticitet:

- Reference til samfundsmæssige problemstillinger, sammenhæng med den daglige undervisning
- Sammenhæng mellem undervisningen i Zoo, Fælles Mål og læseplan.

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**Resultater**

Emnet for undervisningen var elevernes holdninger til dyr, årsagerne til elevernes holdninger og hvordan holdninger til dyr kan have betydning for vores forhold til eksempelvis truede dyrearter.

**Personlig autenticitet**

**Skema 1**  Fokus på om undervisningens indhold er meningsfuld for eleven og knytter an til elevens erfaringsverden.

<table>
<thead>
<tr>
<th>Observationer</th>
<th>Resultater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevernes interesse (at eleverne har fokus på det der foregår i undervisningen og stiller relevante spørgsmål)</td>
<td>Alle undtagen 1-2 elever virker interesserede</td>
</tr>
<tr>
<td>Elevernes aktivitet (at eleverne er deltagende i undersøgelser, stiller spørgsmål og søger svar)</td>
<td>Alle er active</td>
</tr>
<tr>
<td>Forbindelse med elevernes erfaringsverden</td>
<td>Tegneseriernes onde og gode “dyr” ift. virkelighedens dyr</td>
</tr>
</tbody>
</table>

**Spørgsmål til elever**

- Hvad var spændende i undervisningen
  - “At håndtere dyr og præparater”
- Hvad var ikke spændende
  - “En enkelt nævner introduktionen”
- Lærte I noget vigtigt
  - “Udtalelser der relaterede sig til emnet, eks. “man lærte meget om det med, hvordan man opfatter nogle dyr som ulekre og farlige, og nogle som søde, selvom det kan være fuldstændig omvendt” eller “man skal ikke bedømme dyrene på, hvordan de ser ud, selvom de kan se slimede ud”

**Skema 2**  Fokus på om miljøet i Zoo er motiverende for elevernes læring.

<table>
<thead>
<tr>
<th>Spørgsmål</th>
<th>Resultater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beskriv undervisningslokalet</td>
<td>“Fyldt med terrarier”, “der hang en død flagermus”</td>
</tr>
<tr>
<td>Var der noget I godt kunne tænke jer at undersøge</td>
<td>“Skildpadderne, kranierne, ville jeg gerne have vidst hvad var”. “Jeg var meget fascineret af de vandrende pinde”, “slangerne i terrarierne”.</td>
</tr>
</tbody>
</table>

**Spørgsmål til læreren**

- Hvad er dit motiv for at bruge Zoo
  - “At de anvender levende dyr i undervisningen”, “at de formidler stoffet på en anden måde” |
- Oplever du klassen anderledes
  - “De er mere opmærksomme, bedre til at lytte” |
- Hvilke elementer i undervisningen i Zoo virker positivt på elevernes læring
  - “At underviserne tager fat i noget af det eleverne selv har set og oplevet” |

**Samfundsmæssig autenticitet**

**Skema 3**  Fokus på om der er sammenhæng med den daglige undervisning og Fælles Mål.

<table>
<thead>
<tr>
<th>Spørgsmål til læreren</th>
<th>Resultater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Er der en sammenhæng mellem undervisningen i Zoo, Fælles Mål, eller læseplan</td>
<td>“Nej”</td>
</tr>
<tr>
<td>Har klassen arbejdet med emnet før eller efter besøget i Zoo</td>
<td>“Nej”</td>
</tr>
</tbody>
</table>
Skema 4  Fokus på globale problemstillinger.

<table>
<thead>
<tr>
<th>Observationer</th>
<th>Resultater</th>
</tr>
</thead>
</table>
| Spørgsmål til elever | "det gik meget ud på, at vi skulle indse, at en slange er lige så sød som en hamster"  
"alle dyr er søde på deres egen måde"  
"Vi skulle nok have det at vide flere gange og have mere tid til at røre, før det ville ændre noget" |

**Diskussion**
Nedenfor er fremhævet faktorer der, på baggrund af ovenstående resultater, kendetegner undervisningsforløbene i Zoo.

**Indikationer for personlig autenticitet**

**Indikationer for samfundsmæssig autenticitet**
Emnet for undervisningen var elevernes holdninger til dyr som kan være en samfundsmæssig vigtig problemstilling. Eleverne er blevet opmærksomme på deres holdninger til forskellige dyr, men ifølge dem selv ændrer en enkelt undervisningslektion ikke deres holdninger. Samlet set arbejdes der med globale problemstillinger og emner, men eleverne er ikke forberedte, og der er ikke sammenhæng med Fælles Mål eller læseplan.


**Konklusion**

**References**
**Planter, dyr og økologi i furuskogen**  
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**Bakgrunn, mål og rammer**

Forskningstilnærmingen er **interaktiv aksjonsforskning** (Postholm, 2007). Det betyr både aksjonsforskning og aksjonslæring og bygger på et likeverdig forhold mellom forskere og forskningsdeltagere. Et viktig mål er **utvikling** av praksis. Sammen med lærerne utvikler vi undervisningsopplegg med tydelige **kunnskapsmål** og **vurderingskriterier**. Undervisningen skal ha et **metakognitivt** preg og **den utforsknende metode** skal være fremtredende. Sentralt i prosjektet står bevisst arbeid med **læringsstrategier**, knyttet til fag, emner og læringsarenaer. Gjennomføringen av undervisningsoppleggene følges nøye og erfaringene gir grunnlag for **kritisk refleksjon**.

Uteundervisning i naturfag er redusert de siste årene (Dillon et al., 2006; Magntorn & Helldén, 2005, 2006). Min hovedinteresse i prosjektet er å fremme bruken av ekskursjoner og feltarbeid, stimulere til bruk av den utforsknende metoden i uteundervisningen, og å stimulere læringsstrategier som styrker **sammenhengen** mellom naturstudier ute og læring i naturfag.

I undervisningsopplegget ønsket vi å samle erfaringer knyttet til noen didaktiske problemstillinger som er reist i tilknytning til uteundervisning.

Dillon et al. (2006) skriver i sin review-artikkel om “outdoor learning” at noen studier fremhever betydningen av at læringsaktiviteten ute må være nøyaktig utformet, mens andre advarer mot overstrukturerte læringsaktiviteter. Skal feltarbeidet bli vellykket og ha betydning for læring, må det være godt planlagt (Dillon et al., 2006; Magntorn & Helldén, 2005 & 2006). Godt etterarbeid er av stor betydning (Dillon et al., 2006). Det kan tyde på at elevenes interesse for uteundervisning faller fra barnetrinn til ungdomstrinn (Dillon et al., 2006).

Dette arbeidet beskriver planlegging, gjennomføring og erfaringer med et undervisningsopplegg i økologi med veksling mellom praktiske aktiviteter ute og inne, og andre læringsaktiviteter. Hensikten er å dele våre erfaringer med lærere som ønsker å utvikle sin økologiundervisning.

Til grunn for undervisningsopplegget valgte vi tre kompetansemål, hentet fra hovedområdene **Forskerspiren** og **Mangfoldet i naturen** i Læreplanverket for Kunnskapsløftet (Kunnskapsdepartementet, 2006).

Ett forskningsspørsmål var å undersøke om målene kunne brytes ned til konkrete kunnskapsmål som elevene ble godt kjent med, og hvilken betydning det kan ha på læringsutbyttet.

**Opplegg og metoder**
5. klasse består av 22 elever, 10 jenter og 12 gutter, alle rundt ti år. Undervisningsopplegget strakk seg over hele september måned, fordelt på fem dager, 11.30 - 13.30 hver dag. To av øktene ble brukt til ekskursjoner og feltarbeid i en typisk norsk furuskog, 600 m fra skolen, der elevene arbeidet i tre grupper.

**Planter i skogbunnen**  
Hver gruppe samlet inn så mange forskjellige plantearter fra skogbunnen de kunne finne, lagde en utstilling på en hvit plastduk 1m x 1m og tok bilde av utstillingen med engangskamera.

**Dyr i skogbunnen**  

**Undersøkelse av død furu**  

**Terrarier i klasserommet**  
Hver gruppe samlet inn jord, strøfall, planter og dyr til et terrarium i klasserommet.
Vi skrev loggbok fra planleggingsøktene, fra gjennomføringene og fra refleksjonssamtalene vi hadde i etterkant av hver undervisningsøkt.

Elevene gjennomførte til slutt en kunnskapstest der spørsmålene var utformet på bakgrunn av de formulerte kunnskapsmålene.

**Resultater**

Elevene var flinke til å samle planter, arbeidet ble utført med stor iver. Korrekt gruppering av planter i familier og systematiske grupper var vanskelig å få til.

Etter en instruksjon, felles for hele klassen, klarer elevene å sette opp falkfellene på korrekt måte. Fellene samler godt: Spretthaler, kortvinger (rovbiller), andre billefamilier, maur, tovinger, edderkopper, vevkjerringer og midd. Bestemmelsen av dyra til hovedgruppe og oppptellingen vi gjorde i klasserommet under etterarbeidet, viste seg å bli vanskelig å få til på en skikkelig måte.

Elevene syntes det var spennende å undersøke livet i en råtnende furu. De fant levende dyr (barkbiller, skolopendre, edderkopper og midd), soppmycel og mystiske hull og ganger.

Terrariene fanget elevenes interesse; de ga liv til klasserommet og ble spontant undersøkt hver dag. Edderkoppene fikk navn, og rømte maur og biller ble hentet tilbake.

I kunnskapstesten (Kvammen & Brekke, 2008) undersøkte vi om elevene hadde nådd kompetansemålene. Elevene klarer godt å tegne og beskrive det naturfaglige utstyret vi brukte i feltarbeidet. For eksempel klarer 70% av elevene å tegne falkfellen og å gi en god forklaring på hvordan den fungerer. 75% av elevene klarer å skrive fornuftig om nedbrytningseffekten i furuskogen. Litt over halvparten klarer å navngi og plassere vanlige plante- og dyrearter i riktig gruppe.

**Konklusjoner og implikasjoner**

Våre erfaringer fra femte klasse tilsier at skal feltarbeid få betydning for elevenes læringsutbytte, må det ha en stram styring. Programmet må være avgrenset og oversiktlig, og oppgavene må være enkle og robuste, tydelig beskrevet. Vi erfarte også at utholdenheten blant elevene ikke er så stor, elevene blir etter hvert slitne og mister konsentrasjonen.

På forhånd hadde vi utforsket området godt, prøvd ut utstyr og teknikker, avklart hvor aktivitetene skulle utføres og bestemt gruppeinddelingen. Dette er noe av grunnen til at ekskursjonene ble vellykkete. Er ekskursjonen godt planlagt kan læreren "senke skuldrene", hun vet at oppdragene som elevene skal utføre vil fungere og det er enklere å gripe faglige momenter som uventet dukker opp og utnytte dem pedagogisk.

Første gang vi var ute var elevene ganske urolige og ville, mens dette ble betydelig bedre da vi var ute andre gang. Dette kan skyldes at elevene fra småskolen var vant til at skogturer var preget av lek, og at de ikke var innstilt på å vår ekssjons krevde konsentrasjon arbeidet ble utført på en god måte. Våre erfaringer støtter det mange forskere (Dillon et al., 2006; Magntorn & Helldén, 2006) løfter fram som en viktig suksessfaktor for godt feltarbeid med stort læringsutbytte: feltarbeidet må planlegges grundig og elevene må være godt forberedt på hva som forventes av dem.

Vi er helt på linje med de forfattere som skriver om at skolerekker arbeid og utbytte i naturfag er det nødvendig å farge artene i småskolen, og at de ikke er innstilt på å vår ekssjons krevde konsentrasjon arbeidet ble utført på en god måte. Våre erfaringer støtter det mange forskere (Dillon et al., 2006; Magntorn & Helldén, 2006) løfter fram som en viktig suksessfaktor for godt feltarbeid med stort læringsutbytte: feltarbeidet må planlegges grundig og elevene må være godt forberedt på hva som forventes av dem.

For å få til en systematisering, oppsummering og repetisjon var det nødvendig å gå gjennom plantartene og fangst i falkfellene på nytt, inne i klasserommet. Viktige trekker ved plantenes og dyras autokologi ble kommentert, og alt ble skrevet inn i arbeidsbøkene.


Resources for learning science outside schools

Magntorn and Helldén (2006) highlight the importance of students studying small details in nature. Studying the morphological details (feet, antennae, mouthparts, legs, wings) of an insect in a binocular microscope, with good light and high magnification, was found to be very engaging for the students!

A reason for less outdoor teaching is that teachers lack professional and pedagogical competence (Dillon et al., 2006; Magntorn & Helldén, 2005, 2006). Excursion leadership should be part of the teachers’ professional knowledge.

References


Karakterisering og kvalificering af det “uforberedte besøg” på Orion planetariet

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Baggrund, mål og rammer

International research in informal learning indicates that curriculum relevant pre- and post-treatment generally has a positive effect on the cognitive output of a visit to science museums and science centres (Ellenbogen, 2005; Griffin, 2004; Rennie & McClafferty, 1995). All the same, research in Denmark indicates that students often come “unprepared” and have not worked with the visits (Sørensen & Kofod, 2004). This can be due to the teachers’ lack of competence to prepare the students for the visits or that the extra-curricular learning environments have not been able to specify their expectations for how the students’ pre-understanding will be on the topic is not well documented in Danish pedagogical research.

The project has as its main goal, to contribute to increasing our knowledge of the “unprepared visit” and the learning outcomes from such visits, through characterising and qualifying a specific “unprepared visit” at the Orion Planetarium in Jels. The project is an example of how cooperation between different institutions with special focus on teacher training (University College Syd) and special focus on educational means (CFU Åbenraa) can contribute to qualifying the extra-curricular offer from the Orion planetarium.

The project’s subgoals can be summarised as:

- To increase our knowledge of the learning potential in a “unprepared visit” at the Orion planetarium
- To increase our knowledge of the students’ affective output and development of interest in the subject astronomy through involvement with a visit with a different purpose
- To qualify the planetarium's offer and prepare for this type of visit.

Metoder og eksempler

The project has been designed so that the research in the planetarium can be inspired by observation, pre- and post-treatment, interviews and audio-recordings. Observation of the visit was made with video and supplemented by the project group’s individual observations. The students’ visits and post-treatment had a clear purpose to record what the students did at the planetarium and how they operated. They were not told in advance what was expected of them. After the students had been inside the planetarium and made the post-treatment, three students were selected for follow-up interviews. The selection was made in consultation with the teacher and a student assistant with the aim of representing the class from the students’ different academic abilities. 2½ months after the visit, the teacher was interviewed with the aim of understanding the teacher’s experience and the post-treatment.

...

Ifølge Wagenschein bør læreren have en klar bevidsthed om menneskets “læringsgenetiske ophav” og præciserer med sit begreb ”genetisch” det komplicerede i tilgængelsen af naturfaglige begreber og problematikker. De naturfaglige problemer må forstås som stående foran eleven på samme måde, som selv samme problemer har stået foran menneskeheden, da de endnu ikke var løst. Den foragtede mængde af stof, som nye naturvidenskabelige erkenlser og teknologiske landvindinger har medført, har blott øget behovet for en mere ”genetisk” tænkning. Wagenschein referer en kort ordveksling fra et rejseophold for at illustrere modernitetens virkning herpå: ”Wo liegt dennesees Mallorca?” ”Das weiss ich nicht. Wir sind hingeflogen” (Wagenschein 1968).

Ifølge denne tankegang bør eleven få tid til at opleve fænomenet i sin rette sammenhæng. Man kunne dog ganske berettiget indvende, at det ifølge dette projekt er tale om en illustration af virkeligheden ved en planetariefremvisning og ikke virkeligheden i sig selv. Vi mener dog at kunne argumentere for, at også illustrationen af virkeligheden kan være et stærkt naturfagligt fænomen.

Wagenschein fremfører desuden med sit begreb ”Einsteig”, at indgangen til en læringsproces og dermed til et givent naturfagligt stof ikke nødvendigvis går gennem en platform fra et ”lavere kognitivt niveau”. I stedet for at se indgangen til et givent stof gennem de enkelte faglige begreber, argumenterer han for, at man med fordel kan anvende et appetitvækkende indgangsspørgsmål, hvor eleven så gennem afklaringen heraf må fagligere sig med mere komplicerede spørgsmål og tilegne sig faglige begreber. Grundantagelserne bag ”Einsteig” dementerer dermed forestillingen om at tilegnelsen af et givent fagligt stof nødvendigvis er et mindre kompliceret fagligt stof som forberedelse hertil. Wagenschein advarer således mod at forveksle stoffets systematisk med tænkningens og lærings systematisk (Wagenschein, 1968). Med andre ord er indgangen til læring af naturfaglige begreber ikke enstrenget og lineært men kan måske med fordel tænkes som ”knuder” på et tov (platforme jf. Wagenschein), og hvor indgangen til de enkelte ”knuder” ikke nødvendigvis går gennem eller forudsætte arbejdet med tidligere ”knuder”. - Dette om ikke andet problematiserer vores forestilling om nødvendigheden af før- behandling af et besøg på et ekstramuralt naturfagligt læringsmiljø, men præciserer og forudsætter derimod nødvendigheden af de ekstramurale læringsmiljøers refleksion over didaktisk ståsted.

Udgangspunktet for nærværende forsknings- udviklingsarbejde har således baseret sig på Wagenscheins tanker om at give fænomenet en særligstatus i elevens møde med naturvidenskaben, og sikre at fænomenet også får plads og ikke umiddelbart kompromitteres af underviserens gode hensigter om at forberede og sikre effektiv kognitiv forståelse af de naturfaglige begreber. Projektet her bygger således på Wagenscheins hensigter om at give de affektive og interesseskabende elementer en markant plads i naturfagsformidlingen.

Resultater
Det fremgik som et tydeligt resultat af før- og eftertegningserne, at elevernes astronomifaglige viden blev nuanceret, og i flere tilfælde var der tale om en klar forøgelse af det astronomifaglige vidensgrundlag. Enkelte tilfælde illustrerede tegningerne ikke nogen tydelig forskel i vidensgrundlag. Her er et par af de mest illustrative til eksempel, Figur 2, 3 og 4:
Interviewene gav ikke anledning til at afvige ovenstående resultater angående det astronomifaglige kognitive udbytte, men gav en god fornemmelse af det afektive udbytte af besøget. Generelt gav eleverne meget positiv respons på besøget, mens enkelte dog gav udtryk for, at opholdet i planetariesalen var for langt. Alle gav specielt udtryk for deres fascination af planetariesalen, og alle udtrykte forøget interesse for det astronomiske område og lyst til efterfølgende at beskæftige sig med astronomiske emner i N/T undervisningen:
3. kl. pige – formodet midt:
...jeg syntes, det er spændende at vide, hvad der er omme bag ved skyerne og sådan noget. - Det kunne jo godt være, at tingene på jorden dem kender man jo lidt bedre end omme bag ved skyerne..

3. kl. pige – formodet bund:
...Det ved jeg ikke..... - Så ville jeg nok arbejde med solen og landene og sådan noget. ... - Det syntes jeg er rigtig rigtig rigtig spændende.

3. kl dreng. – formodet top.
.....Ja! - Nu vil jeg rigtig gerne arbejde med planeter og sådan noget...

Godt nok var det sikret, at eleverne ikke havde arbejdet med astronomi i skolen før deres besøg på Orion Planetariet, men mange havde kendskab til området fra forældre eller venner og kan således ikke siges at være uden faglige forforståelser. Disse forforståelser var da også af forskelligartet karakter, og specielt kunne det konstateres at naturfaglige forforståelser om universet og religiøse forforståelser blandede sig med hinanden. Her en førtegning og en eftertegning fra den samme 3. kl. elev (Figur 5).

Figur 5  Førtegning og en eftertegning fra den samme 3. kl. elev

Konklusioner og implikationer
At eleverne ankommer til besøget med klare astronomifaglige forforståelser, selvom de ikke i skolemæssig sammenhæng har arbejdet med astronomi er vel ikke overraskende. Det er heller ikke overraskende, at der vil lægge en interessekonflikt mellem et religiøst og et naturvidenskabeligt paradigm inden for et sådant emne. Det er dog væsentlig mere overraskende, at eleverne på trods af manglende skolemæssig forberedelse får et så klart kognitivt og affektivt astronomifagligt udbytte af besøget, som resultaterne viser. Opstartspotentialet til et efterfølgende undervisningsforløb om astronomi er åbenlyst, og den fælles oplevelse at referere til kan give eleverne og deres lærer et fælles ejerskab til forløbet.

Ovenstående projekt kan dog ikke sige noget om, hvad samme elever ellers ville have lært med et forberedt besøg, men indikerer om ikke andet at det "uforberedte besøg" også kan have sin klare effekt både kognitivt og affektivt, hvis besøgsstedets tilbud er målrettet denne type besøgende. Det virker dog ønskeligt, at der foretages yderligere forskning i denne type af besøg, hvor også en regulær sammenligning med det forberedte besøg var ønskelig. Da kvalificeringsdelen af projektet endnu ikke er afsluttet, kan der udelukkende konkluderes på karakteriseringsdelen.

Det er veldokumenteret, at den danske stab af lærere i natur/teknik har vidt forskellige forudsætninger for at undervise i faget. KALK undersøgelsen har således dokumenteret, at kun 48% af lærerne som underviser i faget har en linjefagsuddannelse i et eller flere naturfag, og at kun en meget lille del heraf har en linjefagsuddannelse i natur/teknik (Dragsted, Horn & Sørensen, 2003). Der findes altså mange ikke-uddannede naturfagslærere, der ikke selv ville føle sig kompetent til at arrangere et "forberedt besøg" indenfor emnet astronomi på Orion Planetariet. Der er ikke med ovenstående projekt belæg for at anbefale den danske stab af naturfagslærere minimere deres forberedelse af et besøg på et ekstramuralt læringsmiljø. Det "uforberedte besøg" vil selvsagt også kræve grundig forberedelse og en sikker viden om det ekstramurale læringsmiljøs tilbud og besøgets egentlige indhold. Men der syntes dog belæg for at genoverveje det "uforberedte besøgs" læringspotentiale og samtidigt anbefale naturfagslærere med lav self-efficacy indenfor et specifikt fagligt område ikke at fravælge målrettede ekstramurale læringsmiljøs i frustration over egen manglende kompetence og evne til at forberede sig fagligt på besøget.
Guided dialogue at science centres

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Introduction
Increasingly schools are using external players, such as science centres, to supplement science education. However, research shows that cognitive outcomes of science centre visits are more likely to occur when visits include pre- and post-activities and when the pupils are helped or guided in one way or another to reflect upon their experiences (Griffin, 2004; Rennie & McClafferty, 1995). At the same time research shows that this is most often not the case; many visits do not include pre- and post-activities and the pupils can do as-they-please during the visit (Anderson & Zhang, 2003; Rennie & McClafferty, 1995).

My own doctoral work is no exception. In this work I have investigated upper secondary students’ engagement and outcomes of an non-integrated and unstructured visit to the Danish science centre Experimentarium. The survey shows that emotional, affective outcomes are high while cognitive outcomes in general are low including long-term impacts (Quistgaard, 2006).

Regarding the actual visit, Rennie and McClafferty (1995) posit that students need words. In line with this, Allen (2002) showed that dialogue has great importance for learning at science centres. Likewise DeWitt and Osborne (2007) argue that teachers’ facilitation of dialogue is one of several crucial parameters in student learning at science centres.

The question of interest in this project is how guidance, in the form of guided dialogue at a science centre, impacts students’ reflections and cognitive outcomes. The hypothesis is that guided dialogue led by someone aware of it or trained to do so (such as a teacher or a guide) will set off reflections of various kinds among the students and enable an understanding of the presented phenomena and concepts.

Methodology
The underlying theoretical perspectives are Bakhtin’s concept of dialogism (Holquist, 1990) supplemented by Dewey’s (2005/1916) ideas of learning exchange and mutual dialogue. Based on these theories a pedagogy has been developed involving an inquiry-based facilitation of dialogue and reflection. The survey includes six upper secondary students aged 15-16 years. For practical reasons the researcher took on the role of guide/facilitator. Using the participant-observation approach, the researcher joined each of the six students on a visit to eight exhibits at Experimentarium and recorded the dialogue. At each exhibit the students were asked different types of open Socratic questions, such as: “What do you make of this?”, “Can you relate this to anything in your everyday life?” Further, the students were encouraged to continue when uttering things of interest and showing signs of understanding. At other times students were invited to comment on a particular matter. Examples are: “Do you know this from something in your everyday life?”, “Is this of practical importance?”, “How do you think this is possible?” Other approaches were to encourage dialogue by creating a problem/dilemma or to put forward a related phenomenon or concept in an attempt to make the students wonder about a possible connection to the phenomenon in question.

After the first four events constituting the one-one situation (facilitator-student) it was decided to conduct the fifth event with the two remaining students together. In all five events the researcher did not look for specific answers but was open to any response and aimed to take it from there, giving the students plenty of room and full recognition at all times.
To assess longitudinal impacts, follow-up interviews were conducted one year later. The agenda for the interviews was to encourage statements from the students that could give an insight to their learning and to how they were impacted. For instance, they were asked to describe the visit and to elaborate on these descriptions. Further, they were asked specific questions about the exhibits they mentioned. Also, they were reminded of the exhibits they didn’t remember and asked to reflect upon them.

All recordings and interviews were transcribed and analysed according to the phenomenological analysis model (Kristiansen & Krogstrup, 1999; Kvale, 1997). Accordingly, each of the five events and the follow-up interviews are interpreted with respect to four levels:

1. Descriptive
2. Self-understanding
3. Common sense
4. Theoretical.

**Findings**

For each event the dialogue of facilitator and student is analysed and coded respectively. The former, representing the guided dialogue or inquiry pedagogy that this project is concerned with, is coded in relation to type of question or approach in facilitating the dialogue. The later is coded in relation to the cognitive style and scientific level of the responses. The purpose of this analysis is to unfold how the developed inquiry pedagogy manifests itself and how the student is impacted by it.

The dialogue has further been divided into sequences. A sequence border is placed when the facilitator has to use a new strategy to make the student reflect. Each sequence has been classified according to whether it contains high-level responses or not. Responses are assigned as high-level (level 2 and 3, Figure 1) when the utterance is interpreted as fully or semi-consistent with a scientifically correct definition of the presented phenomenon. To provide a measure for the amount of high-level responses demonstrated by each student the number of sequences containing one or more high-level responses is divided by the total number of sequences identified in the course of each student’s event. The result is an outline of each student’s ability to respond to the guided dialogue and of what scientific level (level 0, 1, 2 or 3) and cognitive style those responses are (e.g. explaining, reflections-in-action, applying).

The results show that indeed it was possible to make the students respond at a high level (Figure 1). Only one out of the six (Girl 1) was less able to respond and reflect, which is interpreted as being due to a low knowledge level of the concepts in question. Although the other five demonstrated many high-level responses they showed clear differences in how they reacted to the guiding. This is interpreted as differences in learning style and knowledge level. The survey shows how the inquiry approach can be adjusted in order to maximise the outcome for each type of student. The most fruitful event was the last one, where two students were guided together. The responses and reflections in this event occurred both in a dialogue with the facilitator and in a learning exchange between the two students. Further, the analysis shows that the most frequent style of response is that of “explaining” followed by that of “reflections-in-action”.

![Figure 1](image-url)  
**Figure 1** Percentage of dialogue sequences containing one or more high-level responses for each student.
Follow-up interviews show that two students have developed knowledge about wind systems in relation to the rotation of the Earth. According to the two students, this knowledge is achieved through guided dialogue at one particular exhibit. They both reported having given a talk in their class about the Coriolis Effect on their own initiative shortly before the interview; that is nearly one year after the event. This particular exhibit is seldom understood by 15-16 years old students (Quistgaard, 2006). There seem to be clear indications that the guided dialogue has been a crucial factor for this impact. Further, the follow-up interviews show that two other students have thought a lot about the functions of the brain, which relates to another particular exhibit.

**Discussion**

The results of the guiding events show the importance of putting experiences at a science centre into words. Further, they show that a guide (e.g. a teacher, explainer) is able to facilitate such reflections of a scientifically high level through an inquiry-based mutual dialogue. The long-term impacts regarding the Coriolis effect demonstrate that such a dialogue can have a substantial impact. The other long-term impacts may not seem so prominent, but seen in the light of earlier work, showing long-term impacts of very little significance, the results are considered important (Quistgaard, 2006).

These findings can serve as a first step into gaining knowledge of how school visits to science centres can seek to maximize the learning potential through a teacher and/or explainer led facilitation of mutual dialogues. It is clear though that the survey has limitations due to the one-one or one-two situation of guiding. Further research will have to show whether this approach is fruitful also in the one-thirty situation as in the instance of a teacher and her class.

**References**


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**Museographic transposition: a didactical approach to museum exhibition engineering**

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**Aim and background**

This paper introduces the framework of museographic transposition as a theoretical approach to museum didactics. By museographic transposition we mean the adaptive transformation of knowledge that takes place in the engineering of museum exhibitions; from the knowledge present in the source material such as scientific literature to the knowledge present in the finished exhibition. The approach is illustrated by a case study: a preliminary analysis of the museographic transposition of the subject of animal adaptations to darkness.

Science museum exhibitions are important educational devices that potentially influence many people. Objectives of such exhibitions are often stated in terms of visitors developing new knowledge, new behavioural repertoires, or new models for interpreting natural phenomena. Yet, there is no body of empirical and theoretical research available to exhibition engineers on how to achieve such goals. The quantity of museum research carried out in the last decades seems to contradict this statement. However, much of this research focuses on visitor learning processes within a given exhibition environment. While this work has provided key insights into learning in informal environments, it is clear that in terms of exhibition engineering, its focus is too far downstream for it to offer more than remedial feedback to the engineering process.
Framework
A useful perspective is offered by the theory of didactical transposition which presents an epistemological approach to teaching by delineating the processes which make an “object of teaching” from an “object of knowledge to be taught” (Chevallard, 1985). A crucial assumption in this theory is that knowledge may exist in different forms, depending on the institutions in which it is developed and circulated, but direct transfer of knowledge between institutions, for example from university research to classrooms, is normally not possible. Instead, to be viable in a new context, knowledge must be adaptively transformed, i.e. transposed, to the conditions of this new context (Chevallard, 1985). For example, a cell biologist may perceive an animal cell as any member of a highly diverse group (e.g. red blood cells, liver cells, epidermal cells), while school textbook illustrations often show a strongly transposed prototypical version of a cell which combines attributes of many different types of cells without corresponding exactly to any single type (Clément, 2007).

Adapting the framework of didactical transposition to museum exhibition engineering, Simonneaux and Jacobi (2007) use the concept museographic transposition to describe the transposition of subject-related knowledge from the source, which is usually scientific literature, into the exhibition planning documents, here called the curatorial brief, and finally into the exhibition milieu, the intent of which is to stimulate knowledge construction among visitors (see Figure 1). In essence, the framework of museological transposition provides a structure with which to conceptualise the sequential phases of the exhibition engineering process and to organise the versions of subject-related knowledge pertaining to each phase.

The reference model (Figure 1) constitutes the standpoint from which an epistemological analysis of each of the versions of knowledge may take place, and is thus the foundation of the approach. The reference model is elaborated from empirical data from each phase of the transposition, and serves as the basic theoretical model for the researcher (Bosch, Chevallard & Gascón, 2006). The reference model must encompass all the pertinent versions of the subject-related knowledge in order for the researcher to avoid defining the transposition process in terms of just one of the phases of the transposition.

Figure 1  Museographic transposition (white arrows). The figure shows how the knowledge contained in source materials (“source knowledge”) such as textbooks, scientific articles, etc. is transposed into the exhibition planning documents: the curatorial brief. From here, knowledge is transposed again into the actual exhibition (“exhibition milieu”). The figure includes the reference model. See text for further explanation.

The following example illustrates the elaboration and use of the reference model. The example is based on a small excerpt of data collected in a larger study.

Case study
The present data were collected in 2007 at the science centre Experimentarium in Copenhagen and pertain to an exhibition unit, a self contained exhibition component entitled Cave Expedition, which is part of a larger thematic cluster labelled Darkness. The cluster is one of five in an exhibition about animal adaptations to extreme environments. Cave Expedition presents the cave beetle Duvalius stankovitch, which is an insect that inhabits permanently dark caves.

The following example illustrates the construction and use of the reference model in the analysis of a single instance of transposition, namely from curatorial brief to exhibition milieu, regarding the concept of heterospecific species, specifically predators, in the cave beetle’s environment (Figure 2).

Figure 2 The reference model for the case study presented in the text considers the transposition from curatorial brief to exhibition milieu for just one exhibit: Cave Expedition.
The curatorial brief: the stated objectives of Cave Expedition
According to the curatorial brief, the purpose of the exhibition unit Cave Expedition is to illustrate, from a human point of view, what it is like to be a cave beetle (Executive Committee, 2005). The exhibition engineers explain: "We wanted to put the visitor in the place of the [beetle]" (M. Stentoft, pers. comm., 21-11-07); "the intent was to let the visitor pretend to be the animal" (P. Velk, pers. comm., 17-11-07).

These empirical data are extrapolated to form the reference model: what are the implications for illustrating the concept of a hetero-specific predator to a visitor who is in the place of a cave beetle? One point, originating in the source knowledge, is that cave beetle predators are usually other arthropods at least an order of magnitude larger than the beetle. Thus, an illustration of this aspect of a hetero-specific predator would be a model of an arthropod an order of magnitude larger than the visitor.

The exhibition milieu: the structure of Cave Expedition
The exhibition milieu of Cave Expedition consists of a darkened tunnel about 10 m long and 1.5 m wide. Along one wall, a number of life-sized (up to 15 cm in length) rubber animals are mounted at a height of about 1 m. The animals are two spiders, a scorpion, a centipede and two lizards.

Analysis
Several restrictions constrain the transposition of the concept of hetero-specific predators from curatorial brief to exhibition milieu. One subject matter related restriction is the choice of lizards to illustrate predators: whereas lizards are common predators of beetles in many habitats, they are ectothermic and thus do not inhabit permanently dark caves. Yet, statements by the exhibition engineers such as the following: "These are the types of animals you’d find in caves. These are the animals that would prey on the beetles [in the wild]" (P. Velk, pers. comm., 17-11-07) indicate that they view lizards as representatives of beetle hetero-specifics.

Another restriction, related to the reality of maintaining an exhibition, is the scale of the models of the hetero-specific predators, the rubber animals. An exhibition engineer explained that due to wear and tear, the models must be replaced quite often. Thus, the choice of the life-sized rubber model animals “…was a practical issue. Which animals were available at the toy store?” (P. Velk, pers. comm., 17-11-07). Thus, the models of hetero-specific predators in Cave Expedition are of a scale that humans, not cave beetles, would experience them.

These examples may indicate an implicit attempt to create a cave environment such as it is experienced by humans rather than by cave beetles. The exhibition unit’s title Cave Expedition further emphasises the human viewpoint, signifying a dichotomy which may be the symptom of competing agendas among the exhibition engineers (Lindauer, 2005).

Conclusions and implications
The case presented does not comprise an exhaustive analysis; rather, it illustrates the use of the model of museographic transposition as a tool for the investigation of one aspect of exhibition engineering. The case demonstrates how a thorough analysis of the subject to be exhibited and the objectives of such an exhibition may illuminate issues that must be resolved for optimal results, but more importantly, how the epistemological analysis of the chosen subject may provide the basis for new ideas regarding exhibition engineering.

References
Executive Committee. (2005). Xtremes: storyline for an exhibition about adaptations to extreme environmental conditions on Earth.
Planning science instruction:
From insight to learning to pedagogical practices

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Synopses:
Learning to teach science

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Learning to teach science
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 (Heldén, 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; Martínez, Sauleda & Huber, 2001) as well as their reasons for enrolling the program. Six months later, when the science and art courses began, 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 is still 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 preschool 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 & Patrikainen, 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 1  Analytical framework (cf. Mortimer & Scott, 2003).

<table>
<thead>
<tr>
<th></th>
<th>Interactive</th>
<th>Non-interactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorative</td>
<td>Question – answer – evaluation</td>
<td>Lecturing</td>
</tr>
<tr>
<td>Dialogic</td>
<td>Discuss – student voice</td>
<td>Reviewing student voice</td>
</tr>
</tbody>
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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.

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
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References


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

Modulising
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>Start phase</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>Middle phase / end phase</strong></td>
<td>Starting point in academic subject didactic systematic Curriculum Content</td>
<td>Starting point in the student - Problem situations - Practical tasks and field trips - Finalised topics</td>
<td>Starting point in the students - Problems - Project course</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.

![Kolb's circle of learning](image)

**Figure 1**  Kolb’s circle of learning

**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
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 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 depends 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:
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 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.
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
- Interview questions to pupil groups designed
- 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
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?
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