Planning science instruction: From insight to learning to pedagogical practices

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The quality of memorable episodes in science education

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Background, aims and framework

This is the third part of a sequence of studies dealing with the developing abilities to \textit{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 \textit{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:

\[\ldots\text{fieldwork can have a positive impact on long term memory, due to the memorable nature of the fieldwork setting and there can be reinforcement between the affective and the cognitive, with each informing the other and providing a bridge to higher order learning. (p. 32)\]

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 \textit{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

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Phase 1:} & \textbf{Phase 2:} & \textbf{Phase 3:} & \textbf{Phase 4:} \\
\hline
*Collect and study the freshwater shrimp and its ecology & *Study organisms adaptations to fast and slow running waters & *Studying predators and herbivores and relate to their morphology & *Relate abiotic and biotic factors \\
*Feeding experiment (litter bags) & *Testing different techniques for collection of animals & *Naming animals and making an exhibition & *Build a food-web \\
*Studying river planst & *Studying river planst & *Make closed systems & *Make river quality test \\
*Use LEGO to illustrate processes (photosynthesis) & & & *Play an ecological game \\
\hline
\end{tabular}

\textbf{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).

![Figure 2](image1.png)

**Figure 2** The episodes recalled by the ten students

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 caddisfly 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.

![Figure 3](image2.png)

**Figure 3** The diagram shows the organisms from the river mentioned by the ten students.
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
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
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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 than 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 become a central concept in Danish science education policy papers (Andersen, Busch, Horst, Andersen, Daigaard, & 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
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include, but are not limited to, providing ample opportunities for people to engage with each other in order to allow for
the necessary support structures to enable dedicated science teachers to become change agents. Support structures
are needed to head educational change, so school leaders need to provide an overall vision for school science practices
Also, in order to avoid creating “individualistic teaching cultures” (Hargreaves & Fullan, 1992) by relying on individual
benefiting the schools that are already thriving rather than the schools that need it the most.

variations in individual schools, development initiatives aimed at improving science teaching across schools may end up
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Consequently, it is important not to assume that what works in one school readily transfers to others. At the level
urbanisation of the area around the school, can pose significant barriers to or opportunities for educational change.

first of all, it emphasises the fact that no two schools are alike. Differences in local conditions such as managerial
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).

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:

Acknowledging 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).

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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 fifteen 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 her 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.

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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).

Rekruttering af flere piger til tek-nat-uddannelser har både stor politisk og forskningsmæssig bevågenhed (Busch, 2004; Troelsen, 2005; Schreiner & Sjøberg, 2007; Osborne & Dillon, 2008). Der er imidlertid en risiko for at problemet opfattes som et problem hos pigerne, ud fra en opfattelse af at piger

Køn og identitet er ikke givet, men konstrueres i et samspil med omgivelserne, hvor kønnet 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, der 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 strukturerer 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 bliver sådan lidt mere drenget”, siger den ene, og en anden tilfører: ”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 pigeernes 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 nedæmper 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 erklære 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 var enige eller helt enige.

For at opnå en legitim position på uddannelsen må pigerne distancere sig fra dominerende forestillinger 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.

Det er væsentligt at hæfte sig ved at også drengene indretter sig efter modsætningen mellem faglig kompetence og kropslig fremtræden. Eleverne fortæller om drenge som efter et stykke tid bliver mere neutrale i deres fremtræden.


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 kænnene, 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 drege 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 ger 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.


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**Haptic influences on reasoning and learning in protein education**

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*Gunnar Höst*

**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).
Pedagogical practices

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>
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<th>Dynamics</th>
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<td>48</td>
<td>26</td>
<td>11</td>
<td>7</td>
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</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
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 studiemønstre 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 frit og fremst 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 tidligere 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 frekommende kategorier betragtes som kvalitative forskellige måder at forholde 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

Der blev nedsat en tværfaglig projektgruppe med repræsentanter dels fra etnologi, dels med uddannelsesforskere indenfor naturvidenskab, sundhedsvidenskab, farmaceutisk videnskab samt ingeniørvidenskab. Undersøgelsen af Damsholt et al. (2003) omfattede nuværende og tidligere studerende på humaniora. Da det var hensigten at udvikle et skema der uduover humaniora dækkede naturvidenskab og naturvidenskabelige professionsuddannelser, blev der først foretaget en interviewundersøgelse med yderligere 15 informanter fra farmaceutstudiet, medicinstudiet, ingeniørestudiet og fysikstudiet med henblik på at validere de fundne studiemønstre fra humaniora og udvide med eventuelt nye studiemønstre. I analysen heraf fremkom yderligere et studiemønster:

- 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 forfinne 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 temærene i matricen endeligt inddelt i ni overordnede temaer der tydeligt kunne adskilles og med inspiration fra narrativerne blev matricen omsat i 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 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 kørt på omdefinerede skalaer og, bortset fra en enkelt tilføjelse til justeringer, passede de observerede data til Raschmodellens krav. De seks studiemønstre kunne 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 bilde. Der er enkelte spørgsmål der giver anledning til tvivl om fortolkningen hos respondenterne.

Fordelingen af studiemønstre på fag indeholder flere interessante elementer (Figur 1).
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Studiemønstre som funktion af fag

Figur 1 Studiemønstre som funktion af fag

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 studiemønster 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.

Implikationer

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
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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

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 (Menntamálaráðuneytið, 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.

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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 (Sandoval, 2003; Schaubel 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.
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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


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
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