Planning science instruction: From insight to learning to pedagogical practices
Proceedings of the 9th Nordic Research Symposium on Science Education
11th-15th June 2008, Reykjavik, Iceland
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Planning science instruction
Teacher educator and student teacher conceptions of teaching and learning

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

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

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

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

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

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

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

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

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

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

1. The subject taught in school
2. Subject-teacher is an entity
3. The subject is transferred to the student
4. The subject is exposed to the student
5. Student prior knowledge is related to the concept structure of the subject
6. The subject is seen as a human construction

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

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

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

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

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

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

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

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

III: The subject is transferred to the student

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

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

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

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

IV: The subject is exposed to the student

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

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

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

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

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

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

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

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

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

VI: The subject is seen as a human construction

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

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

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

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

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

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

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

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

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

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

<table>
<thead>
<tr>
<th>Conception: Experience of:</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The subject taught in school</td>
<td>Subject-teacher is an entity</td>
<td>The subject is transferred to the student</td>
<td>The subject is exposed to the student</td>
<td>Student prior knowledge is related to the concept structure of the subject</td>
<td>The subject is seen as a human construction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nondualistic relation content and thought</th>
<th>Mapping of student’s prior knowledge (teachers’ perspective, misconceptions)</th>
<th>Description of students’ conceptual development (students’ perspective)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Concepts/Conceptual Development</th>
<th>Learning</th>
<th>Student role</th>
<th>Teacher role</th>
<th>The subject</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The student actively creates her own knowledge (learning style)</td>
<td>Student listens, receives, repeats and &quot;learns&quot;</td>
<td>To lecture and demonstrate</td>
<td>The subject taught in school</td>
</tr>
<tr>
<td></td>
<td>The student constructs concepts according to subject’s development</td>
<td>Student investigates, experiences and discovers</td>
<td>To clarify, simplify, convey, assist and “teach”</td>
<td>Subject-teacher is an entity</td>
</tr>
<tr>
<td></td>
<td>The student constitutes concepts and thereby the subject</td>
<td>Student’s prior knowledge is revealed in various ways</td>
<td>To provide well chosen situations to enable learning</td>
<td>The subject is transferred to the student</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>To search for student’s prior knowledge and work towards set objectives</td>
<td>The subject is exposed to the student</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Student prior knowledge is related to the concept structure of the subject</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The subject is seen as a human construction</td>
</tr>
</tbody>
</table>
The staircase of teaching – a tool for learning and reflection

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

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

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

References


Students’ understanding of photosynthesis

A study in three small rural schools in Iceland

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Halldóra Lóa Thorvaldsdóttir

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

Background, aims and framework

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

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

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

According to the National Curriculum in Iceland from 1999, 10 year old children are expected to:

- explain what components are essential for photosynthesis to happen,
- explain what the products from photosynthesis are, and
- explain what role photosynthesis has for the world’s ecosystems (Ministry of Education, Science and Culture, 1999, p. 49).

At age 14- 15 students are expected to be able to:

- describe the energy needs of organisms and how they get their energy,
- explain cellular respiration and photosynthesis and how the relevant chemical processes connect,
- describe the specialization of chloroplast and mitochondria, and
- know which organisms can carry out photosynthesis (Ministry of Education, Science and Culture, 1999 p. 69).

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

Methods and samples

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

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

<table>
<thead>
<tr>
<th>Question</th>
<th>% right answer</th>
<th>5th grade</th>
<th>9th grade</th>
<th>Most common wrong answer (% and option)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No 1</strong> What are the outcomes of photosynthesis?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. CO₂ changes into O₂</td>
<td>21</td>
<td>39</td>
<td>63- i</td>
<td>54- i</td>
</tr>
<tr>
<td>ii. the plant can breathe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. the plant can make nourishment from inorganic matter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. plants can get rid of waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No 2</strong> Through which body part does the plant incorporate CO₂?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. through the roots</td>
<td>33</td>
<td>60</td>
<td>22- iii</td>
<td>50- i</td>
</tr>
<tr>
<td>ii. through the leaves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. through the stems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. it does not take up CO₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No 3</strong> The food stuff of plants is made of:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. water and soil</td>
<td>56</td>
<td>52</td>
<td>33- i</td>
<td>33- i</td>
</tr>
<tr>
<td>ii. CO₂ and soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. glucose</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. water, CO₂, minerals and the energy of the sun</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>No 4</strong> Plants need light:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. to produce nourishment</td>
<td>62</td>
<td>55</td>
<td>32- iv</td>
<td>34- iv</td>
</tr>
<tr>
<td>ii. to reproduce</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. so that insects can see them</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. so that water can evaporate and thus become available for photosynthesis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No 5</strong> Plants:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. need constant light so they can get nourishment</td>
<td>30</td>
<td>28</td>
<td>46- i</td>
<td>35- i</td>
</tr>
<tr>
<td>ii. do not need continuous light so they can get nourishment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. are not dependent on light to get nourishment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. need more light in some seasons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No 6</strong> The chloroplast:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. has the important role to make the leaves green and attract insects</td>
<td>67</td>
<td>70</td>
<td>22</td>
<td>16- i</td>
</tr>
<tr>
<td>ii. has the important role to harness the sun’s energy to produce nourishment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. reflects the green waves of the light</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. has no important role</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No 7</strong> Water is:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. a necessary component in photosynthesis</td>
<td>51</td>
<td>77</td>
<td>38- iii</td>
<td>16- ii</td>
</tr>
<tr>
<td>ii. an important molecule but not in photosynthesis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. rather necessary but not essential for plants</td>
<td></td>
<td></td>
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<tr>
<td>iv. only necessary for animals</td>
<td></td>
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<tr>
<td><strong>No 8</strong> Which of the following statement is not correct? Photosynthesis occurs in:</td>
<td></td>
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</tr>
<tr>
<td>i. flowers and trees</td>
<td>37</td>
<td>38</td>
<td>24- ii</td>
<td>33- ii</td>
</tr>
<tr>
<td>ii. plants and some protista</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. plants and algae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. only plants</td>
<td></td>
<td></td>
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<tr>
<td><strong>No 9</strong> Oxygen flows into the atmosphere when:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>i. plants breathe</td>
<td>11</td>
<td>48</td>
<td>65- i</td>
<td>43- i</td>
</tr>
<tr>
<td>ii. animals breathe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. plants deliver waste</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>iv. when organic molecules rot</td>
<td></td>
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<td></td>
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<tr>
<td><strong>No 10</strong> Do algae photosynthesize?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. yes</td>
<td>49</td>
<td>62</td>
<td>24- iv</td>
<td>18- iii</td>
</tr>
<tr>
<td>ii. no</td>
<td></td>
<td></td>
<td></td>
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<td>iii. only when they need to</td>
<td></td>
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<tr>
<td>iv. no, they get food like animals</td>
<td></td>
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</table>
The four questions that the ninth graders answered in their own words were:
1. What use do the plants have for light?
2. What role does the chloroplast have?
3. What is the difference between glucose and starch?
4. Why do plants need food stuff/nourishment?

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

The results are remarkably similar for the two age groups. Pupil misconceptions seem to prevail in spite of additional teaching and more detailed explanations in the textbooks. What many of the older pupils have though clearly learned is where the uptake of CO\textsubscript{2} takes place (it is covered in the teaching material for the 8th class), and that oxygen is the byproduct of photosynthesis. The misconception that photosynthesis is the process where CO\textsubscript{2} is changed into oxygen is very strong (Question 1). Also, the misconception that respiration in plants produces oxygen is very common for both age groups (see Question 9).

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

Conclusions and implications
The results show that majority of pupils in the sample have a poor understanding of the concept and processes of photosynthesis. Only 40% of 15 year old students and 20% of 10 year old students know that through photosynthesis organic matter is produced from inorganic molecules and energy from light. The process of photosynthesis is not well understood and the majority believes that the purpose is to change CO\textsubscript{2} into oxygen. Also, the 9th graders did not do much better than the 5th graders although students have lessons in cell biology including cellular respiration and photosynthesis in grades 6-8. Our results show that 15 year old students do not seem to realize that plants also need nourishment, (a source of energy) to function and that the same law applies to them as animals regarding respiration. Similar findings have been reported from other studies (Bell, 1985; Driver, Squires, Rushworth & Wood-Robinson, 2003; Yenilmez & Tekkaya, 2006).

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

References
The influence of the teaching materials used in class on children’s ideas about the human body

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

Background, aims and framework

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

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

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

Some misconceptions are quite common and may be very resistant to change. It is therefore important for the teacher to be aware of them and be able to respond appropriately when they occur (Farmery, 2002). Educational experiences can lead to misconceptions or maintain misconceptions. Clément (2003) talks about didactical obstacles to learning that come from contradictions between previous teaching and scientific knowledge and suggests that primary school textbooks can, by making things simple, maintain misconceptions. According to him many of the earlier French primary school textbooks often draw “the way of the food” from mouth to anus, with precise times: a boy is eating an apple at
lunchtime, one minute later the apple is in the stomach and 14 hours later it reaches the anus. Clément says this is a big mistake as this is not the “way of food”, but the way of what is not digested as in these drawings, the blood is absent. Clément’s work suggests that identification of didactical obstacles could help in proposing more effective pedagogical strategies.

In a Portuguese study on children ideas about digestion; one classroom from each grade (year 1 up to year 4) was selected randomly within the same primary school. The youngest children were asked to make a drawing in order to obtain information about their conceptions of digestion, and individual interviews were carried out with pupils whose drawings were difficult to understand, while year 3 pupils were asked to write short texts about digestion (Carvalho, Silva, Lima & Coquet, 2004). Two types of learning obstacles were detected on the basis of the origins of children’s concepts. These are the ones gained from the daily life (epistemological obstacles) and those gained from formal learning activities (didactical obstacles). After teaching about digestion, the children’s conceptions of anatomy of the digestive tract changed completely, the drawings were more realistic and less symbolic. The results from the study showed clearly that school teaching about digestion and the digestive system can cause major changes in pupil thinking. The drawings suggest that the children were especially influenced by the figure of the digestive process in the school textbook (Carvalho et al., 2004). After teaching about digestion the great majority of children reproduced the textbook schema in their own drawings. They did not show the continuity of the digestive tract and showed confusion in the anatomy and connections of the small and large intestine. None of the 120 pupils in the study drew the passage of digested products into the blood. Twenty three per cent of year 3 pupils, however, mentioned ‘blood absorption’ when asked to write a short text about the digestion of a cookie, although they did not show it in their drawings. However, the researchers think these comments were made after learning by heart rather than from understanding, as most of the primary school textbooks mention ‘blood absorption’ without an explanation of what this means.

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

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

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

• How do the ideas that Icelandic children bring to primary school change over the course of the first two school years during teaching about the human body in relation to location and structure (bones, muscles, heart, lungs, brain, digestive-system), function (of the heart, skeleton, lungs, brain, stomach) and processes (digestion and blood circulation)?

• How are changes in pupil ideas affected by the curriculum, teaching methods, teaching materials, teacher-pupil and peer interactions, or other factors?

In this paper a special focus will be on the influence of the teaching materials used in class.

**Methods and sample**

One class of 19 Primary One children and their teacher were chosen to take part in the research which continued in Primary Two. The research tradition used in the study can be described as ‘eclectic’ since a number of research methods were used in order to get information from different perspectives to increase the validity of the conclusions (Bogdan & Biklen, 2003). These methods were classroom observations, interviews, drawings and diagnostic tasks. The children were asked to draw pictures at every stage of the study right from the beginning, before teaching about the body started and to the end. Several different methods were also used to analyse the data. All the drawings were collected and special scales were used to analyse them (Reiss & Tunnicliffe, 1999). Classroom observations and interviews were analysed by using elements from grounded theory and discourse analysis, where discourse analysis was used to give a clearer picture
and understanding of how certain words and concepts were used and understood (Banister & Parker, 1994; Lofland & Lofland, 1995). A special form was also developed to analyse the drawings, the interviews with the children and the diagnostic tasks.

**Results**

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

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

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

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

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

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

Figure 1  A illustration of a human egg and sperm cells. The drawing is adapted from the textbook used by the teacher (Óskarsdóttir & Hermannsdóttir, 2001a, p. 2).

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

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

Figure 2  A drawing of the main muscles in the upper arm adapted from the textbook used by the teacher (Óskarsdóttir & Hermannsdóttir, 2001a, p. 10) and two examples of children’s drawings of the muscles.

There is a picture in the Big book that is supposed to illustrate the circulation system (Figure 3).
Figure 3 A drawing of the circulation system adapted from the textbook used by the teacher (Óskarsdóttir & Hermannsdóttir, 2001a, p. 14) and a drawing of the heart, lungs and blood circulation made by a child.

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

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

Figure 4 A drawing adapted from the textbook used by the teacher (Óskarsdóttir & Hermannsdóttir, 2001a, p. 17) and a drawing of the food inside the stomach made by a child.

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

There are two similar pictures of the brain in the Big book. Both show a side view of a grey brain with a brain-stem extending down from the brain. When the children drew the brain many of them drew it with the stem down from one side as they might have inferred from the illustration in the book (Figure 5).

Figure 5 A drawing of the brain adapted from the textbook used by the teacher (Óskarsdóttir & Hermannsdóttir, 2001a, p. 9) and two examples of drawings of the brain made by two children.
The teacher also used the books, *The magic school bus. Inside the human body* (Cole, 1996) and *Svona erum við/That is how we are* (Kaufman, 1976) to emphasise her points and add to the discussion. She used *The Magic School Bus* when explaining the blood circulation and the way the food goes through the body when she put on little drama acts. She used *That is how we are*, when talking about the brain and showed them a detailed picture of the brain in the book and some of the children had that picture clearly in mind when drawing their own picture of the brain.

**Summary and discussion**

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

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

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

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

**Conclusions and implications**

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

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

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

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

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

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

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

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

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

In 1987 an evaluation of the physical science middle school materials in 1987 was carried out on behalf of the Ministry of Education, Science and Culture (Macdonald, 1987a, 1987b). These materials were based on an experimental approach to science. In the mid-1990s the NCEM decided to produce new science materials for lower secondary school and by the late 1990s it was clear that teachers would need new materials in order to teach the revised curriculum of 1999. The task of producing a series of books for middle school physical and earth sciences was put out to tender. Earth sciences were a new area in the science curriculum and overlapped in part with the geography curriculum. The materials were to be developed in close cooperation between the NCEM editor responsible for science and the author. According to the NCEM and our own interviews the materials appear to have been well-received by many teachers and are used each year in several hundred classrooms involving about 4000 or more learners per age group.
Planning science instruction

Classroom observations in the schools in Iceland have shown that “teachers depend to an inordinate degree on the textbooks, for teaching methods as for content” (Sigurgeirsson, 1993, p. 274; Karlsson, 2007). This study contributes to an understanding of the textbook itself and the way in which a science textbook developed for a specific context might influence the ‘science story’ being told to young learners. The books are analysed according to a scheme (hereafter DKS scheme) for textbook analysis developed in Greece by Dimopoulos, Koulaidis and Sklaveniti (2003, 2005). It also draws on an analysis of books as ‘cultural objects’ according to a scheme (hereafter the IMMG scheme) developed in Spain by Izquierdo, Marzabal, Marquez and Gouvea (2007). A key part of the latter scheme involves what is called ‘communicability’ in which the books are analysed in terms of the model of science, the model of the reader and the didactical model being proposed in the textbooks.

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

**Frameworks for analysing textbooks**

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

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

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

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

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

**Methods and samples**

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

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

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

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

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

**A mixture**
In the atmosphere there are many different gases. Among these are three elements, nitrogen (N\textsubscript{2}), oxygen (O\textsubscript{2}) and argon (Ar) and two compounds, carbon dioxide (CO\textsubscript{2}) and water (H\textsubscript{2}O). The molecules of these elements and compounds can not combine with each other. The molecules can only mix. Therefore the atmosphere is not called a compound but a mixture.

Salt water is a mixture of two compounds, water (H\textsubscript{2}O) and salt (NaCl).

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

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

**Formality** is however moderate since the text is neither highly scientific and formally represented, nor does it use colloquial language. There is some use of specialized terminology (symbols of chemicals) and the number of nouns in a row does not exceed two nouns per time (in Icelandic). The sentences are clear with simple structure and there are equally many verbs in passive voice as in the active voice (in the Icelandic text).
Visual images
Legends
Groupwork
“Nuggets”

Figure 1 Student’s textbook, *Auðvitað* 3, page 12 - 13

Table 1 Linguistic analysis of two chapters of an *Auðvitað* book

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

<table>
<thead>
<tr>
<th>Classification</th>
<th>cm²</th>
<th>Formality</th>
<th>cm²</th>
<th>Framing</th>
<th>cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>1055</td>
<td>35%</td>
<td>High</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Moderate</td>
<td>423</td>
<td>14%</td>
<td>Moderate</td>
<td>288</td>
<td>10%</td>
</tr>
<tr>
<td>Weak</td>
<td>1525</td>
<td>51%</td>
<td>Low</td>
<td>2715</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>3003</td>
<td>100%</td>
<td></td>
<td>3003</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>3003</td>
<td>100%</td>
<td></td>
<td>3003</td>
<td>100%</td>
</tr>
</tbody>
</table>

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

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

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

Analysis of visual images

Example 2

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

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

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

---

**Figure 2** Student’s textbook, *Auðvitæð 3*, page 14 - 15
Table 2  Analysis of visual images in two chapters of Auðvitað.

<table>
<thead>
<tr>
<th>Classification criteria</th>
<th>Formality criteria</th>
<th>Framing criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Realistic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Conventional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Hybrid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Narrative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Analytical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Classificational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Metaphorical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Elements of the technoscietific code</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Colour differentiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Colour modulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Contextualisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Eye</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and horizontal angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Medium/distant and oblique</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Distant and frontal or close and oblique</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Close/medium and frontal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Classification</th>
<th>cm²</th>
<th>Formality</th>
<th>cm²</th>
<th>Framing</th>
<th>cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>233</td>
<td>High</td>
<td>95</td>
<td>5%</td>
<td>Strong</td>
</tr>
<tr>
<td>Moderate</td>
<td>514</td>
<td>Moderate</td>
<td>972</td>
<td>47%</td>
<td>Moderate</td>
</tr>
<tr>
<td>Weak</td>
<td>1325</td>
<td>Low</td>
<td>1004</td>
<td>48%</td>
<td>Weak</td>
</tr>
<tr>
<td></td>
<td>2071</td>
<td></td>
<td>2071</td>
<td></td>
<td>2071</td>
</tr>
</tbody>
</table>

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

The degree of formality represents the degree of abstraction in the image. The results show that 95% of the visual images are evenly split between moderate or low formality. That means an emphasis is on colourful images, their background is simple or from real photographic situations and few or no geometrical shapes or alphanumeric strings are present. Nearly 70% of the images are analysed as having weak framing indicating that the images are viewed from a high and frontal angle and from a close or medium distance.

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

Discussion and implications

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

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

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

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

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

References


Naturfaglæreren i møtet med eleven som IKT-bruker
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George Sundt George.Sundt@hist.no

Abstrakt: IKT har høystatus som læringsverktøy i Norge, maskintettheten er stor, det satses betydelig på IKT-opplæring. Samtidig viser undersøkelser begrenset databruk i naturfagene. Eisner beskriver undervisning som en kunstart som fordrer tilstedeværelse i nuet mens Max van Manen hevder forutsetninger for å fungere som dyktige pedagoger er opplevelsen av inspirasjon. 2002-2003 (n=782) og 2008 (n=516) gjennomførte vi spørreundersøkelser blant 9.klassinger i Trøndelag der vi blant annet ønsket å se hvorvidt elevene opplevde naturfaglæreren i forhold til faglig og IKT-teknisk fokus og hvordan elevene mente læreren klarte å møte læringsbehovet. Begge undersøkelsene viser at IKT sjelden benyttes. 2008 oppga ca 50 % av de tenårene at de ikke fikk faglig forbindelse rundt ulike tema når IKT ble benyttet som hjelpemiddel mens 66 % sa at læreren brukte mest tid på veiledning under selve IKT-arbeidet. Det er varierende syn på graden av kontakt med læreren under IKT-relaterte arbeidsformer med en tendens til at elevene mener de har mindre kontakt ved bruk av IKT. Det kan stilles spørsmålstegn ved om grunnen til den lave bruken er at lærerne fortsatt opplever usikkerhet knyttet til teknisk/praktisk bruk og at kompetansen ikke er god nok, eller om lærerrollen/faglig fokus under bruk av IKT endres så mye at lærerne opplever at IKT er lite egnet. Uttrykt potensial. Fleksibel IKT-bruk vil kunne utfordre læreren til å være mulighetsåpen og ta nye sjanser. Dette vil kunne være med på å øke den naturfaglige forståelsen.

Innledning


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

Metode

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

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

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

**Lærerrollen ved bruk av IKT i naturfagene**

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

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

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

**Kontakt med lærer under IKT-arbeid**

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

Teknisk bruk

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

Lærerrollen og kontakten med elevene under IKT-bruk

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

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


Konklusjon


Litteratur


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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

References


The importance of science lab work

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

Background, aims and framework

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

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

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

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

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

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

Methods and sample

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

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

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

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

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

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

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

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

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

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

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

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

Explaining to a group that has not done the same experiments
In many groups there were lots of discussions and questions. Only a few sequences were categorised as being unistructural. The categories corresponding to structures of higher quality were more common when students explained their experiments to other groups than during the lab work discussions. The intervention with ideas from Brown (1992) seems to stimulate student ability to use science knowledge. All groups but one had relational categories. Almost 40% of all the statements fall into relational categories.

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

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

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

**References**
Student study orientations and responses to teacher regulating approaches in science

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

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

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

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

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

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

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

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

Conclusions and implications

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

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

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

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


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

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Abstract
In this study aeronautical engineering students' views of physics lessons were investigated in a dialogic/interactive (Mortimer & Scott, 2003) talk between a student and a discussion partner in an interview situation. The background is that the current physics course had a compulsory task when students solved context rich problems, and the discourse when students were deep in conversation during small group work with problem-solving was analyzed (Enhag, Gustafsson, Jonsson, 2007). A main finding in that study was that one student's personal ideas, experiences and questions often drove these group talks. We concluded the physics course with student interviews that had more the qualities of a dialogic/interactive talk around physics as subject-matter, rather than final questions for students to make a statement about. The aim was to highlight students' personal ideas about physics lessons. The pattern for the transcribed student/interviewer conversation showed partly exploratory talks (Mercer, 1995, 2000; Barnes & Todd, 1995) between the student and the interviewer. The paper presents six students' own ideas developed during the exploratory talk parts of the conversation. The focus of the analysis is how the talk around 20 start questions elucidates student ideas after prompting utterances from the discussion partner/interviewer. The research questions are: 1) What personal ideas do the students bring into the discussion? 2) What ‘unexpected’ questions and utterances does the discussion/partner interviewer prompt the student with to get deeper into the student ideas? Several of the 20 starting questions in the 'interview guide' developed a talk that was exploratory and dialogic/interactive. The way to prompt the students with supportive questions and encouragement helped them to reach a deeper meaning and expression of their ideas.

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

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

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

The paper presents examples of students personal ideas developed during the exploratory talk parts of the conversation. The focus of the analysis is how the conversation talk related to 20 support questions, elucidates student personal ideas, after prompting utterances from the discussion partner/interviewer. The research questions are:

1) What kind of personal ideas do the students bring into the discussion?
2) What ‘unexpected’ questions and utterances does the discussion/partner, interviewer, prompt the student with, to get deeper into the student ideas?

Methods and samples
One month after their physics course the students were invited to take part in the interviews/talks and were informed about the research purpose. The teacher was informed about the interviews/talks going on. The class had earlier been divided into two groups and to be able to handle the interviews only one group was invited to the interviews/talks, and 13 out of the 16 students came as volunteers. The interviews were open ended around a few themes that all students responded to. The themes were:

1. student experience from different physics courses in school,
2. student experience from the recent physics course that had included lectures, two laboratory sessions and three sessions with small group work with context rich problems,
3. ideas about group work and laboratory work,
4. learning physics, and
5. remembering physics activities.
An interview guide was developed with 20 questions to have as a support to the discussion partner/interviewer to get the conversation going. The conversation was tape-recorded and eight interviews have been transcribed verbatim, and the others partly.

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

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

Example 1 Student C
The first main student-driven idea is about the time limitation she had felt during all her physics courses in school, as well as during the first course at university. She argues for more time to be allocated to physics lessons. She thinks the teacher has not enough time for each student, and that there is not enough time for the students to keep up during lectures. In the exploratory talk, the interviewer prompts the discussion with the words ‘…and what is it then you would have liked this time for…’ that gives feedback and keeps the discussion going. She wants the time for discussion with the teacher about her personal questions that arise when she studies herself at a slower pace, questions she now never is able to ask in class.

Her second main idea is about how physics is analogous to a sport. The initiating question from the interviewer is “How do you view physics in school? Is it difficult or easy, is it important?”. The student expresses herself with half sentences (the typical explorative way). She finds that physics is analogous to a sport; you need to train a lot to be good at it. The talk becomes more intense when the interviewer gives her the prompting question: ‘…What is the aim with the sport physics then?’...
Example 2 Student I
Student I’s main idea is how the context is much more important than formulas and calculations. In the exploratory talks the interviewer prompts him to continue develop his ideas by asking “What do you mean by context here…?”

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

<table>
<thead>
<tr>
<th>Interviewer:</th>
<th>What do you think about physics in school? Is it difficult or easy, is it important?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student C:</td>
<td>It is like, well, any sport… it is important to spend time on it, and train, and practice…</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>It was fun how you see it as a sport…</td>
</tr>
<tr>
<td></td>
<td>Yes, I see it like that for math too… if you don’t use it, you will forget it, and that makes you worse at it too…</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>What is the aim with the “sport” physics then….</td>
</tr>
<tr>
<td>Student C:</td>
<td>What is the aim with the sport physics… well... it is maybe to … learn how to … you get another type of thinking… if you say so… well… some issues are taken for granted… if you learn physics then you see things from another point of view… and of life also… you notice that … planet Earth… not … well, you are not alone here… so it is so… so much… with physics you get answers to so many questions… you can get answers to how things work but not why they work… and that is a bit frustrating… or why it is as it is but it is more scientific this way… sometimes it is good to know how things work but it is also annoying not to know how…</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Interviewer:</th>
<th>Are you able to explain to a friend why an airplane can fly?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student S:</td>
<td>Yes, sure!</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>You feel you can. Could you do that already at high school?</td>
</tr>
<tr>
<td>Student S:</td>
<td>Yes, I had the basis as I was interested in flying. I did fly before I came here. I have read about it on the Internet and I have read a few books too.</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>How did you find out about your interest in flying?</td>
</tr>
<tr>
<td>Student S:</td>
<td>Already as a child. There were not so many airplanes in my life in my country… it was the military that bombed us. I had not been able to fly before. When I flew to Sweden from Syria that was the first time. Then the interest was really aroused.</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>Yes? It was the flight itself then…?</td>
</tr>
<tr>
<td>Student S:</td>
<td>Well, I was interested in all these flying military things. And when you the came closer to the airplanes, heavy, big. A body lifting into the air. You get interested! Everybody in my family was sitting there next to me. They were so afraid and so, when we touched down. But I wanted to sit at the window and look down… the others said ‘hi, close the window’ they didn’t want to look down, but I was so interested.</td>
</tr>
<tr>
<td>Interviewer:</td>
<td>How old were you? Did you think “I want to fly or build an airplane”?</td>
</tr>
<tr>
<td>Student S:</td>
<td>I was 15. Well, not to build one, but to fly one. And, I was so unbelievably glad to fly …. It was how the air hostesses treated us on the plane, and how the captain talked to us through the radio…. and how everybody clapped their hands when we touched down…. it was such fun. You wanted to continue with airplanes you see. One wanted to continue to study something within aeronautics.</td>
</tr>
</tbody>
</table>
Example 4 Student J

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

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

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

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

Example 5 Student K

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

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

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

2 Some student utterances about physics lessons in general

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

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

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

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

3 A summary of the student experiences of group work

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

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

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

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

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

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

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

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

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

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

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

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

There are several ways to look at teacher/student talk. One is to see conversation as a tool with which the teacher orchestrates the lesson, and by that an obligation for the teacher to be aware of the importance of the different classroom talk qualities. Analyses of classroom talk by the communicative approach (Mortimer & Scott, 2003) show that most talk in the classroom is driven by teachers, an authoritative/interactive talk where teachers ask questions and evaluate student answers. The dialogic/interactive talk, where student give their views of physics related topics, is a rare thing in the teacher/student talk in the classroom.

A second way to look at the teacher/student talk is to see this discourse on physics as a possible agent of change both from a content point of view for the benefit of student ownership of learning and for changing the culture of physics in school. Emphasizing more talk in the classroom raise hopes for enhanced physics teaching and increased student co-operation and ownership of learning (Enghag, 2006). This way of taking time to find out about students personal ideas and views, one by one, is also a useful instrument, to teach with dialogic/interactive talk, when it is managed in the
classroom involving several students and with physics concepts in focus.

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

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

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

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

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

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

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

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

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

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

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

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

<table>
<thead>
<tr>
<th>Profile of implementation</th>
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<tbody>
<tr>
<td>Ideal</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Classroom interaction</th>
<th>Practical work (fieldwork, assignments, outdoor work)</th>
<th>The nature and role of science in society</th>
<th>Assessment</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Capacity to support innovation</th>
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</thead>
<tbody>
<tr>
<td>Ideal</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Teaching resources (e.g. books, laboratory, teachers)</th>
<th>Teacher factors (e.g. background, expertise, and career)</th>
<th>Learner factors (e.g. background, ability, attitude, behaviour)</th>
<th>School leadership and management</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Ideal</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Learning community</td>
<td>Professional development, support and assessment</td>
<td>External and self-evaluation</td>
<td>Only external evaluation</td>
</tr>
<tr>
<td></td>
<td>Example</td>
<td></td>
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</tr>
</tbody>
</table>

Types of encouragement and support

<table>
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<th>Physical resources</th>
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Figure 3  Support received from outside agencies for innovation and curriculum implementation (developed from Rogan, 2007)

Self-evaluation of science provision

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

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

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

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

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

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

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

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

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

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

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

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

**The zone of feasible innovation in curriculum implementation**

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

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

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

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

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

References