IARTEM *e-Journal*
Volume 3 No 2

Volume 3 Number 2

Learning Chemistry: Text Use and Text Talk in a Finland-Swedish Chemistry Classroom

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Abstract

The article draws on the notion that the process of gradually becoming part of new social contexts always involves a gradual enculturation into the discourse of the field, and also that the responsibility of the educational systems is to give students opportunities to develop their literacy competence in various subject areas. The article also argues for an explicit text focus in science classrooms, due to the complexity of texts used in the area, especially regarding multimodality. For the purpose of discussing these issues, an analysis of literacy events in a chemistry classroom has been done. The starting point was to investigate what semiotic resources connected to a multimodal concept of texts were used, and how, with a special interest in meta-textual classroom discussions. The results of the analysis reveal that the students come across a number of different texts in the chemistry classroom, but that longer running texts neither are read nor written in the classroom and that almost no meta-textual discussions take place. Pedagogical implications of the results are discussed.

Introduction

A fundamental responsibility of the education system today - from pre-school to university level - is the development of literacy competence among students. However, there is a growing consensus that we cannot regard school literacy in a singular sense, but instead must consider that there are a number of literacies (e.g. Schleppegrell 2004, Unsworth 2001), and also that learning a (school) subject should involve a gradual enculturation into the discourse of the specific subject (e.g. Halliday & Martin 1993, Macken-Horarik 2002, Schleppegrell 2004, Rose 2005, Unsworth 2001, Wallace 2004, Wellington & Osborne 2001). In order to fulfil such aims, schools must provide students with a learning context in which they are given opportunities to become gradually more familiar with and involved in working with disciplinary genres. As Norris & Phillips (2003:226) state, regarding science education in schools, “reading and writing are constitutive parts of science”. A natural consequence of such a stance is that we cannot separate the subject content of any school subject from the texts used in learning that content.

This paper presents results from a study of chemistry classroom practices in a Finland-Swedish classroom and is part of an interdisciplinary project financed by the Swedish Research Council (Chemistry texts as tools for scientific learning: a comparative study of teaching practices in Swedish and Finland-Swedish classrooms) - with a special focus on text use. The analysis is framed within the multimodal perspective (e.g. Jewitt & Kress 2003, Kress 2010, Kress & van Leeuwen 2001) and an extended, multimodal, concept of text is used (e.g. Kress & van Leeuwen 2001, Kress 2010).

Within the multimodal perspective, it is presupposed that a variety of semiotic resources can be used to shape or represent knowledge (e.g. Kress 2003, Kress & Jewitt 2003, Kress et al. 2001, Selander & Rostvall 2008). In chemistry education in school settings, a number of semiotic resources can be discerned, for example artefacts such as objects used in experimental work (test tubes, Bunsen burners, evaporation bowls, etc.), various types of written texts – both written texts in the ”traditional” sense (written words on paper, sometimes combined with various sorts of illustrations) and texts that can be defined from an extended (or multimodal) concept of text (e.g. Karlsson 2007, Kress & van Leeuwen 2001) (chemical formulas, tables, pictures, etc.) – as well as gestures (e.g. when the teacher uses gestures to illustrate a model of the atom). We can also expect that an increasing number of these resources – perhaps especially those that are text based – would be at hand and dealt with by means of various electronic media (Jewitt 2005, Bezemer & Kress 2008). If we perceive learning as a developing ability to handle an established set of semiotic resources used in a particular domain of learning (Selander 2008:34), chemistry learning is a process in which the learner becomes gradually more familiar with using a number of different tools and symbols, some of which are based on texts. A fundamental aim of the project is to highlight what semiotic resources are used in chemistry classrooms, and to investigate what kind of learning these resources make possible, and the ways in which teachers and students deal with them. This paper focuses on resources that can be linked to the extended text concept.

Background

In previous research of text use in science teaching and learning, the focus has often been on textbooks (e.g. Digisi & Willett 1995, Driscoll et al. 1994, Edling 2006, Knain 2002). One could question this, since there are a number of potential text resources, both texts produced and presented by ways of traditional media (printed texts, writing on paper and blackboard, etc.) and new technologies (texts on computer screens, videos, digital pens, and SMART boards, etc.) (e.g. Jewitt 2005, Bezemer & Kress 2008), as well as both mono-modal and multimodal texts. However, textbooks appear to be important in more ways than to what extent they are actually utilised in the classroom. The textbook is often used as an important source for deciding what content to teach, as well as in what order the various topics of the curriculum should be addressed.(Englund 1999, Fang 2006, Harniss et al. 2001, Knain 2001, Selander 2003). The present study aims to present an overview of the kinds of texts available present in a classroom as well as what communication that contextualises them. In this aspect, the textbook is treated as simply one text among others.

Using a systemic functional perspective of grammar (e.g. Halliday 2004), Schleppegrell (2004:115ff) describes a number of text elements – or 'genres'– typical of scientific discourse, each element with its specific structure. These elements have different functions and can be used in for example: instructions, explanations, recounting of procedures after experimental work, and scientific taxonomies. They can be combined in so called *macro genres* (see e.g. Martin 1997), i.e. texts containing a number of specific text elements; one example in chemistry is the experimental report. When analysing the various components that build up a genre, terms like *stages* (Unsworth 2001), or *text activities* have been used (for an overview of the ways in which the notion of genre and adjacent terms have been used in text research, see e.g. Holmberg, 2010). These text activities, genres and macro genres can all be found in the chemistry classroom, and to become familiar with and being able to use (and (re)produce) these are an important aspect of learning chemistry.

The language used in textbooks – in science as well as in other subjects – can be criticised from both structural and other aspects (e.g. Martin 1998, Schleppegrell 2004). Ekvall and Berg (2010) discuss various potential obstacles in the actual textbook used in the classroom in focus, such as partly suppressed information and an unclear information structure. Furthermore, diagrams, pictures and tables can be difficult to interpret (e.g. Bowen & Roth 2002, Peacock & Cleghorn 2004, Stylianidou et al. 2002). Textbook texts can also be regarded as divergent in relation to the genres of the scientific discourse and the ways in which these are realised outside the school context. However, if students are able to master these genres, which are sometimes described as hybrids between everyday language and scientific language, it is possible that this mastery can be a valuable skill when confronted with other scientific texts outside school.

As regards the use of textbooks in science classrooms, a number of interesting investigations can be mentioned. Based on a classroom study of grade 8 in middle school, Driscoll et al. (1994) describe a situation in which students were reluctant to use the textbook in the classroom – apart from treating it as a kind of reference book, especially when preparing for preparing for tests. Their study also revealed that there were no activities concerning how to use the textbook, though the teacher worked actively with other kinds of learning strategies. Knain (2002) reported a similar result from interviews with Norwegian teachers and high school students, concerning their attitudes to and usage of textbooks in physics. The students claimed that they appreciated the textbook but that they, too, mainly used it as a reference book in connection to tests. In a study by Digisi and Willett (1995) biology teachers in high school reported that they integrated a number of reading activities when teaching lower grades, while this was not the case when teaching higher grades. Instead, they expected students in higher grades to learn the subject partly by ways of independent reading. However, even though text reading took place in these classrooms – particularly in earlier grades – and teachers regarded reading activities important, they seemed uncertain as to how to integrate reading strategies with teaching subject content.

In another Swedish project (e.g. Edling 2006, Geijerstam 2006), various aspects of texts and text use in different school subjects were investigated in connection to classroom studies in various school grades. Edling (2006:46) reported that 93 % of the texts read in all of the classrooms were from textbooks, and in the science classroom, the textbook was the only text that was used. However, an important difference between Edling's and the present study is that Edling surveyed text use in a more traditional way and texts written on the blackboard were not included in her survey. Edling describes typical activities around text in the physics classroom in year 8 (2006:151ff). According to this study, the activities around preparation and follow-up of text work were limited, typically beginning with the teacher's monologue as introduction, followed by the students' individual reading and an activity of a reproducing type. This analysis revealed that a great deal of writing in these classrooms was never followed up by teachers. Moreover, the texts generally had no function for the students after they have been written. Neither did conversation around texts take place to any large extent in the classrooms.

In his overview, Selander noted some years ago (2003), that research on textbook use was scarce – something that still seems to be the case (see also Danielsson & Ekvall 2008). Thus, the present study can contribute to a better understanding of this aspect. In the overall project, textbooks used in the classrooms are analysed (e.g. Ekvall & Berg 2010), but in the present paper, all texts present are given the same importance – textbooks as well as the teacher's notes on the blackboard, etc. – a perspective that to my knowledge has been more unusual in previous research (Lemke, 2000, is an exception).

Finally, since the present study was performed in Finland, a short comment on Wikman (2009) is relevant, even though his article mainly deals with what characterizes good textbooks. In his text, Wikman refers to a Finnish article from 2008 by Atjonen et al., revealing "an extensive use of textbooks in Finnish schools" (*ibid*. p. 2) something which he claims could be one possible reason for Finland's success in international surveys like the PISA studies. Hence, from the study Wikman reports, it is plausible that we would find the textbook to be used quite frequently in the Finland-Swedish classroom in the present study.

Text work in classrooms

As stated earlier, the enculturation into the genres of disciplines has to be a natural part of learning every school subject. However, there are various ways in which a learning situation could be dealt with to meet such demands. It could either involve a context in which the students, without an explicit text focus, participate in a rich textual and linguistic environment, thus being given various opportunities to learn genres inductively. Or it could involve more explicit teaching, in which the teacher both emphasises the content *and* textual aspects when dealing with various texts within the content area, focusing on adequate aspects of importance for the various semiotic resources, and in this way presents the students with strategies for reading and writing texts within the content area. The latter view is advocated within the *SFL pedagogy*, or *educational linguistics* (e.g. Christie 2005, Fang 2006, Halliday & Martin 1993, Macken-Horarik 2002, Schleppegrell 2004, Rose 2005, Unsworth 2001, Wellington & Osborne 2001), developed in Australia and based on Halliday's systemic functional grammar (e.g. 2004). Another approach is *Questioning the Author,* QtA, developed by Beck & McKeown (e.g. 2006) – initially for teaching literature, but further developed by Reichenberg (e.g. Reichenberg 2005, Reichenberg & Axelsson 2006) to be used in Swedish social science classrooms.

The aim of QtA is to emphasise that there is an author behind every text and that the author has made a number of choices, both regarding content and linguistic aspects, and also to foreground these choices in classroom discussions between the teacher and the students. Another important aspect of this approach is to recognise that if the student finds it hard to engage, this may not be due to the student's (lack of) abilities, but might be due to choices made by the author. This active approach to reading texts is believed to help students to develop reading strategies characterised by a high activation level, something that can be linked to the concept of *text movability* (see Edling 2006).

In the cyclic Reading to Learn methodology (e.g. Rose 2005), based on SFL pedagogy, the teacher and students engage in reading and writing in parallel, beginning with a mutual close reading of a text, then gradually moving towards more independent work in which the students as a last step write their texts individually. This explicit teaching method involves both reading and writing, while Questioning the Author mainly aims at developing students' reading strategies. Even though the latter method only concerns reading, there is a possibility that a strong emphasis on active text reading could also lead to a development of the students' writing competence. If this is the case, this would mean that through explicit focus on effective and critical reading strategies, students might in an implicit way obtain tools for developing their own writing.

The SFL pedagogy can be (and has been) criticised for being too lenient when it comes to critiquing the power of existing genres, thus generating students that just accept and reproduce the norm (see Kress 2003:89). However, it can be argued that only those who are familiar with, and master the genres considered to be the norm can change them in deliberate ways (see van Leeuwen 2008:40). My stance is that if teachers work explicitly not only with the content of texts, but also with the ways in which the various linguistic, pictorial and other resources are utilised in them, this could improve students' literacy competence as well as helping them to grasp the content area itself. This would especially be the case for students that might not be familiar with the school genres and the underlying, often implicit, expectancies school has when it comes to language use within the school context (see also Gibbons, 2002, for a discussion).

No matter what method we use when combining a text focus with content in classrooms, the method chosen always has to be adapted to the specific demands of the texts in use. Questions typically used within QtA, such as "What is the author trying to say?" or "What do you think the author means by that?" (Reichenberg & Axelsson 2006) might not be the most relevant questions in connection to science school teaching (though quite interesting if the students reach a fairly high level of meta-textual understanding). Instead, since science texts have a high level of multimodality, and the use of abstract models, symbols etc. is highly important in explaining scientific concepts (Lemke 1998, 2000), a focus on multimodality might be a fruitful way of dealing with texts in the science classroom. This is especially the case since we cannot take for granted that all students by themselves can code the often complex ways in which different semiotic resources relate to each other and to scientific concepts. A way of dealing with this could be by a close reading of both the wordings and the range of abstract models used in the textbook, in order to make explicit how words and models complete each other. Also such a perspective can give the students guidance as to how to “read” abstract models. More naturalistic pictures and photographs, can be more or less “taken in”, while models often need a closer reading. So with inspiration from QtA, the teacher might discuss aspects such as “Why is this particular model chosen for this concept?”, “In what ways – and why, do you think – does the model of the atom on this page differ from the model on that page?” Pictures are often conceived as unproblematic to (re)code, but when dealing with abstract models this is certainly not the case, and a student (or teacher) who regards pictures as something that authors or publishers use to make texts more appealing might be mistaken. In the school context, science texts might be the first texts that students come across in which this is not the case.

The study

Aims

The aims of the study are twofold. Firstly, it aims to survey the extent to which different kinds of texts are used in classroom practice. Secondly, it aims to analyse in what ways texts are made visible and the opportunities that exist for enculturation into the subject’s genres, as well as the potential for explicit work with texts – such as joint writing, or meta-textual discussions. As regards the second aim of the analysis, it is assumed that explicit text work would boost the students’ possibility of enculturation into the genres. In this perspective, it is interesting to investigate to what extent we can find classroom work with a text focus of the type advocated for example within the framework of SFL pedagogy or by Beck and McKeown (e.g. 2006). Furthermore, literacy events (Barton 2007, Heath 1983) – around which there is no explicit text focus – are interesting as to the inherent potential they might have.

Thus, the main research questions in the present study are:
- To what extent are texts (i.e. the extended concept of text) used in the classroom?
- What types of texts are used and in what situations?
- To what extent does explicit work around texts and/or meta-textual discussions take place in the classroom: and if so, how are they put into practise and who initiates them?

To answer these questions a thorough analysis of video recordings and photographs taken in the classroom has been conducted.

Methods

Subjects

The study was carried out in eighth grade in secondary school in a Finland-Swedish classroom outside a medium sized town in Finland. The area has a large Finland-

Swedish population: the majority of people in the community speak Finland-Swedish as their first language. There are Finnish speaking schools in the area but this particular school was monolingual in Swedish, and all students in the class regarded Swedish as their first language. The students (7 girls 7 boys) were 13–14 years of age when the investigation took place. The teacher is an experienced teacher of science and mathematics and his first language is Finland-Swedish. All names are assumed, so as not to reveal the identities of the subjects.

Data collection and analyses

All chemistry lessons during a period during which the class worked with the periodic chart, acids, bases and chemical bonds were video recorded, with one camera focusing on the teacher and the overall classroom activities and two cameras focusing on two pairs of students. All activities during the lessons around these four so called "focus students" (three girls, one boy) were video recorded. In addition, all texts they encountered or wrote during the lessons were digitally photographed. As was mentioned above, an extended, multimodal, text concept has been used (e.g. Kress & van Leeuwen 2001), including labels, charts, and pictures. Consequently all such texts present around the students were collected during the period of observation. Since not only digital photographs were taken of text produced, but video cameras also focused four students, the ways in which these students worked with their texts as well as the ways in which they dealt with other texts in the classroom could be followed in detail. Altogether 22 lessons were observed, and the present study focuses especially on the 7^{th} and 8^{th} lesson, although data from other lessons is also used to give an adequate representation of the overall learning situation concerning text use in the classroom.

Towards the end of the observation period, the four focus students and the teacher were interviewed individually in semi-structured interviews (Kvale 2007), i.e. a number of questions were prepared, but depending on the answers given, the subjects were encouraged to elaborate their answers in different ways.

The video recordings and photographs were analysed as to what extent texts were used in the classroom and what types of texts were present in what kind of situations. The ways in which the texts were used and to what extent the students themselves produced text were scrutinized. The communication (between teacher and student as well as student-to-student) that took place around literacy events in the classroom was also analysed to investigate to what extent any meta-textual communication occurred. In connection to this, the various phases (preparation, text work, follow-up) surrounding reading and writing activities were analysed. As regards these phases, only general observations will be presented.

Sometimes approximate translations of fairly rough transcriptions from the lessons and interviews are used to shed light on various aspects of interest. A transcription key is found at page 28. Also when citing e.g. the textbook, approximate translations from Swedish has been made.

Results

Texts in the classroom: an overview

A number of texts were present in the classroom, including a textbook, the teacher's notes on the blackboard, the students' notes in their notebooks, the periodic chart, worksheets, labels on vessels containing chemicals, texts posted on classroom walls (both texts connected to science and other texts), and finally, to some extent, the students' private texts. Among these, the most prominent texts in the classroom were i) the teacher's notes on the blackboard ii) copied by the students in their notebooks, and finally, iii) the periodic chart (on a screen in front of the classroom and as a spread in the textbook).

Textbook use

The textbook had a prominent role in the classroom in the sense that it was present almost the whole time: all students always brought it to the classroom and usually kept it on the desk in front of them during the lessons (often with the spread with the periodic chart in front of them, or sometimes with a spread with all chemical elements arranged alphabetically). Also, the students were given pages in the textbook to prepare as homework from one week to the next – and sometimes to answer questions connected to that section – and the final test was built solely on a section of the textbook. However, in the actual classroom situation, the book was only rarely focused on by the teacher or the students. Thus, by only looking at the actual *use* of the textbook in the classroom, could researchers report the impression that the textbook was not a very important text.

Figure 1 Book spread with the periodic chart

When the students were given homework in the textbook – this was done when the lesson was about to end – and usually the preparation was limited to telling the students what pages to read:

Teacher: take up your book and I will tell you what pages to prepare ((leafs through some pages)) .. 96, 97, 98 .. 96, 97, 98 .. in this section ((holds up the book and looks at it)) thanks for today ((the students leave the classroom)) (Lesson 2, Sep 2007)

At times the information was (also) written on the blackboard:

Teacher: what are you going to have as homework
Student: (xx)
Teacher: well . ((looks in the book)).. ”the atom becomes an ion” at page 104 and 105 ((leafs through some pages)) and page 110 exercises one to five .. /.../ it is important that you think this through yourselves now . we can go through them later .. I’ll write this down . I’ll write this down . the atom becomes an ion 104 105 ((writes on the blackboard)) and question one to five at page 110 ((writes on the blackboard)) ((the students leave the classroom)) (Lesson 6, Sep 2007)

The transcription above is an excerpt from the lesson when the homework was given for the lessons in focus. Apart from telling the students what pages to read and what questions to answer, the teacher said that it’s important that the students “think this through” themselves. How to act when “thinking through” the content was never discussed.

At the beginning of the first lesson in focus here, the teacher started off with noting what questions the students had problems with, and then ran through these. When doing this, the teacher focused on giving the right answers, often by using the periodic chart. This mainly consisted of a teacher monologue, but from time to time students were given closed questions which they gave short answers to. The run-through is also commented on below when dealing with classroom practises around the periodic chart.

During another lesson, the teacher commented on how to use the textbook in a strategic manner. This was done during a lesson in which the students were told to work with textbook questions they had not yet been given as homework. The introduction was again a monologue by the teacher, but one student asked for a clarification:

Teacher: /.../ now we were supposed to do some experimental work but ... instead ... we’re going to do like this . page one two three .. or one hundred and twenty-three ((the students pick up their textbooks)) there you can find one to five .. and you are supposed to ... answer these questions in your notebooks and the information is found in the preceding pages . that is where the acid section starts /.../ here you can find the answer to your questions /.../
Student: where did you say we can we find the answer?
Teacher: you find them in the chapter just before .. or .. the questions are found at the end of a chapter and therefore you can .. you can leaf back (Lesson 16, Oct 2007)

In this case the teacher was explicit when telling the students to “leaf back” to find answers to questions (something which was never said when introducing homework). Then he walked around the classroom, and a number of times when students expressed that they had difficulties finding the answers he pointed at text boxes in the section, e.g.:

Teacher: what makes a solution acidic? if you don't remember you can look .. there ((points in the book at a text box)) /.../ ((walks around the classroom and turns to another student pair)) the answer can often be found in the shaded boxes /.../ (Lesson 16, Oct 2007)

This was also one of few instances in which a student initiated a conversation with the teacher. The student asked for help finding an answer ("What makes a water solution acid?")

Student: teacher
Teacher: yes
Student: is the answer to 1a somewhere here ((points in the text))
Teacher: mm ((points in the text)) actually it is here where you say you have found it
Student: is it (xx)
Teacher: ((reads aloud from the book)) "when the acid molecule emits its hydrogen ion, it is immediately surrounded and this results in a positive oxonium ion" ... but it also says here at the next page ((reads aloud from a shaded text box)) "the degree of acidity in a water solution is caused by the positive oxonium ion" (Lesson 16, Oct 2007)

Here, too, it is obvious from the teacher's comment that shaded text boxes contain important information, even though he was not explicit about it.

The atomic model and the periodic chart

A text that was often in focus during the teacher's overviews was the periodic chart on a screen in front of the classroom.

Figure 2 Screen with the periodic chart
Error! Reference source not found.

The screen was pulled up and down a great number of times during the overviews and the teacher pointed at different chemical elements, groups (columns) and periods (rows). The students normally also had the book spread with the chart in front of them on their desks. Here it is worth noting that the students came across a variety of designs of the periodic chart, both in the textbook and in the classroom, but the ways in which these differ (or why they do so) was never brought up.

When the lessons in focus took place, the periodic chart had already been introduced. The transcription below is an example of the typical communication around the chart. The conversation took place during the follow-up of the homework commented on above and deals with a task in which the students were supposed to draw a model of the atom for a number of chemical elements, in this case potassium (K):

Teacher: /.../ OK . let's start with number five . and to your delight we are going to look at this wonderful map ((pulls down the chart)) that is so clear .... number five was to draw a bit .. let's start from the end ((writes '5a' on the blackboard))... that is to draw ... what do we say .. ((reads in the textbook)) <u>potassium</u> .... all electrons are supposed to be visible ... how

	many electrons are there in the K-atom? now you have to look at the information ((points at the screen with the chart)) you're not supposed to . we don't expect you to remember by heart . ((changes his voice)) how many electrons are found in the potassium atom ((uses his normal voice again)) then everyone is supposed to answer like this mm ((turns to the chart again)) now let's find potassium . where is it? ((points at the chart)) what number . what atomic number in the periodic chart . who has done this? Katarina what number is it?
Katarina:	20
Teacher:	20 ((looks at the chart and then back at the students, turns to some other students, short silence)) next? <u>Karin</u>
Karin:	19
Teacher:	19 .. what is Ca? <u>Kurt</u>
Kurt:	calcium (Lesson 7, Sep 2007)

During the conversation the teacher said that they were going to "look at the information" and then that they were going to "find potassium", statements that imply that the atomic number contains important information for solving the task. The student who was first asked to answer the question about the atomic number of potassium had mixed up potassium (K, number 19) and calcium (Ca, number 20). Here it is worth mentioning that in Swedish, K (potassium) is called *kalium* and Ca (calcium) is called *kalcium*, wherefore students quite easily mix these two chemical elements up. The teacher did not directly comment on this mistake, but instead repeated the wrong answer and then passed the question over to another student (by saying "next"), after which a third student was told to say what Ca (implicitly number 20) "is". When the teacher started to go through how to draw potassium he turned to the student who had mixed the elements up:

Teacher:	OK . but you have drawn calcium . don't erase it . it's probably a nice model . but draw potassium (Lesson 7, Sep 2007)

The student was not told to correct the model she had drawn from the wrong presupposition about what symbol potassium has. Instead she was told to keep it, since it probably was "nice". What was meant by "nice" (was it a correctly drawn model of the wrong chemical element, was it meticulously drawn, etc.?) was however never explicated. After that, the teacher started drawing a correct model of potassium, involving the students. As can be seen from the transcription, the teacher was implicit about the fact that an atom has the same number of electrons (negative particles) and protons (positive particles).

Teacher:	then there are fewer [electrons] than Katarina has drawn . now I'm going to draw the nuclear charge .. how many positive charges should I indicate in the nucleus .. <u>Kerstin</u>
Kerstin:	19
Teacher:	19 . plus 19 ((draws on the blackboard)) . like that .. and then let's start with 19 electrons .. can someone explain how to draw .. 19 electrons (Lesson 7, Sep 2007)

Then the teacher asked questions about how many electrons should be placed in each electron shell and what each shell is called, until he had drawn a correct model of potassium on the blackboard. The number of electrons in each electronic shell is a somewhat complex question, especially for those who had done (and remembered) previous homework in which a table in which the maximum number of electrons in each electronic shell was indicated. When that homework was discussed in class some time was devoted to the ways in which the number of electrons in each shell can be calculated using a mathematic formula. According to the formula, the M-shell can in principle hold 18 electrons, but during this run-through the students had to accept the fact that a new shell (the N-shell) was needed when eight electrons had been drawn into the M-shell. Why this is so was never discussed and the teacher just commented on it with “this is higher chemistry” and “then some funny things happen”.

When working with this task, the teacher acted somewhat inconsistently when the students contributed with information about how to draw the right number of electrons surrounding the nucleus. After having received correct answers as to how many electrons there should be in the first two shells, the teacher drew clear circles around the nucleus, with small dots on, indicating the number of electrons. After having received a correct answer about the number of electrons on the third shell, he did not draw a circle. Instead he showed with gestures that there was no electron shell for the next eight electrons and he looked demandingly at the student who had given that answer, and the student clarified: “no I meant that it should be in the next shell”. After having drawn a third shell with eight electrons, the teacher asked another student not only to say how many electrons there should be, but also what this shell is called (something which he did demand from the other students):

Teacher:	((draws a third shell with eight electrons)) here we have eight .. so far we have 18 electrons altogether .. so... after that? Kajsa?
Kajsa:	(xxx)
Teacher:	try to say which .. what is the shell called where there is supposed to be one electron?
Kajsa:	N (Lesson 7, Sep 2007)

When the teacher ran through the next question (a question in which the student was supposed to arrange atomic elements according to their chemical characteristics) he returned to the periodic chart.

Teacher:	the chemical characteristics depend on the electronic structure and what in this structure is the important thing .. is it that the inner shell is full .. is it the total number of electrons .. or what could be important? ... <u>Kerstin</u>
Kerstin:	mmm the electrons in the outer shell
Teacher:	in the shell that is farthest out it is the electrons that can be found furthest away from the nucleus .. and then . we can say like this .. it is . organised here ((pointing at the chart)) in a special way so that you can find electrons with the same number of electrons in the outer - sorry <u>atoms</u> .. with the same number of electrons in the outer shell . and for example .. where do you find /.../ atoms with one electron in the outer shell? where?
Student:	(xxx)
Teacher:	in the first group . that’s fine . OK . can you name some chemical elements in the first group ... eh . well <u>Kristina</u> ((Kristina says sodium, potassium, lithium and hydrogen))

Teacher: OK . there came the first four that we have dealt with ((gestures up and down the first column of the chart))

(Lesson 7, Sep 2007)

Here the teacher gestured distinctly as to where to find the first group in the chart. Then he went on to check whether any elements from the first group were mentioned in the question in which elements should be grouped according to chemical characteristics, and he did the same thing with a couple of more elements/groups, and explained how to solve the task:

Teacher: OK .. /.../ what you could do is to check in what group the first one belongs and then you check whether any other elements belong to the same group and then you group them according to that (Lesson 7, Sep 2007)

When going through this task the students were given explicit instruction about how to go about it. However, this conversation, too, is characterized by the teacher's monologue in which the students gave short answers on direct requests from the teacher.

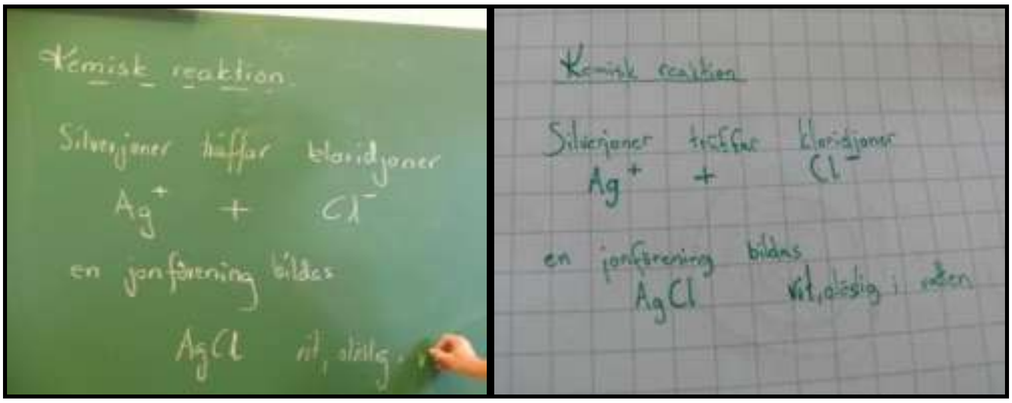
Teacher's and students' notes

One type of text use that occurred regularly was the blackboard notes during the teacher's overviews. These often consisted of schematic models of atoms or ions, of examples of chemical compounds, or instructions before experimental work. In parallel with these notes, students made notes in their note books.

Figure 3 Teacher's blackboard note: model of the atom

The teacher used the blackboard a great deal, but during the weeks when we were in the classroom none of the students ever made any notes on it. However, during one of the lessons in focus the teacher tried to make students do this, but his requests were met by massive silence and he gave up.

Figure 4 Teacher's blackboard notes and student's copy



An interesting finding in this classroom was that students almost never made any other notes than mere copies of the teacher's notes on the blackboard, apart from some note taking in connection to experimental work. At the beginning of the term the teacher had instructed the students to make sure they separated "theory" from notes connected to experimental work in their notebooks, suggesting that they could use their notebooks from two ends, making notes from experimental work starting from the end of the notebook (however, in this way the connection between theoretical explanations and experiments would not be evident). The habit of doing direct copies of the teacher's notes was so confirmed in the classroom practice that the students sometimes missed aspects of the content if these were not written down by the teacher, even when the teacher was very clear in his oral wordings about how to perform experimental work, what notes to write down, etc. One example of this was when the teacher prepared for experimental work dealing with ions, in which the students were supposed to blend two chemical compounds solved in water – silver nitrate and sodium chloride – to see what happened. During the preparation the teacher drew pictures of three test tubes and requested the students to note what the solutions looked like, but he only wrote the words "Vad ser jag" ["What do I see"] beside the third test tube, wherefore many of the students never noted what the original solutions looked like.

Figure 5. Teacher's instruction and student's copy in connection to experimental work

Also, if the students did not have to copy the teacher's notes, the teacher was very clear about this:

> Teacher: you don't have to write this down since we're only doing this for the sake of discussion .. here I write that you have three test tubes /.../ (Lesson 8, Sep 2007)

By copying the teacher's notes, the students made their own, short, textbook, based extensively on the teacher's rewording of the content. In an interview with the teacher he confirmed that he regarded his notes on the blackboard an attempt to create a textbook. He expressed his scepticism towards the textbook which was relatively new for the school, and he commented on it as being "much too embellished" and that it could be especially difficult for "inexperienced readers" to make the effort to read through the text, and that he thought that many students might have difficulties finding the answers to the questions in it.

> Teacher: surely it can be interesting to add words and make it sound fancy like ((reads aloud)) "many of the natural colours in plants can serve as acids or bases" /.../ and so on /.../ for sure it's nice to have this whole story . but at times there is too much story and principally this means that this is the reason why it's difficult to find the important thing /.../and that's why I make notes on the blackboard . short things that they have in their own note books and this could be a support when reading . if it's long like this I can write it shortly on the blackboard "indicator: indicates with a shift of colour acidity or degree of alkaline" just short instead of the whole story (Interview, Oct 2007)

From the transcription above, we can note that the teacher reformulates the wordings of the textbook into a nominal style, i.e. a language in which processes, which are normally expressed with verbs ("the solution *shifts* colours") are instead expressed in nouns ("with a *shift* of colour"). In *systemic functional grammar* (Halliday, 2004), the use of an "incongruent" grammatical form (i.e. a process expressed with a noun instead of the congruent choice, to express it with a verb,) is called a 'grammatical metaphor'. The use of grammatical metaphors, and especially nominalisations, is regarded typical of scientific prose (e.g. Martin 1998, Schleppegrell 2004).

Usually the teacher made no comments as to how the students should write (that they copied the blackboard texts was presumed) or why to choose a specific wording, etc. But in one of the lessons in focus he commented on writing a heading:

> Teacher: /.../ write "working with ions" as a heading /.../ and then you can see what you have done later if you look for it (Lesson 7, Sep 2007)

Apart from writing it on the blackboard the teacher thus explicitly told the students what to write and that the words were supposed to function as a heading in order to make it easier for the student to find the section more easily.

During preparation for experimental work, the teacher also gave an explicit instruction that the students should write down what substance there was in each test tube and where to draw the test tubes:

> Teacher: we are going to make two solutions .. therefore I can draw one test tube and another a small distance away from it . here I write "silver nitrate in water" ((writes)) .. here you write "sodium chloride in water" ((writes)) /.../ (Lesson 7, Sep 2007)

As was mentioned above, the students sometimes used their note books to write down answers to textbook questions. Normally this was done in connection to homework, but this was also the case in connection to one of the lessons in focus. Parts of the run-through of these questions have been commented on above. During the follow-up of the homework the teacher chose to concentrate on a couple of questions that he sensed that the students had had problems with. One of the questions he chose not to comment on (”What is the reason behind the characteristics of the chemical elements?”) is a prerequisite for solving a task that the teacher did bring up (”Group the following chemical elements according to their chemical characteristics”). The reason why the students did not say that the first task was problematic might be that the answer to this can be found directly in the text while a prerequisite for the other question is that the student has understood the first question and also can apply this knowledge to group the elements.

During the run-through, two focus students (Karin and Kerstin) started looking at their answers to the first question on their own, and they both leafed back and forth in the textbook and read each other’s answers and pointed at where they had found their respective answers. A closer look at what they had written in their note books revealed that they had copied different key sentences from the textbook and (Karin: “What all elements in one group have in common is that they have the same number of electrons in the outer shell”, Kerstin: “The number of electrons in the outer shell”, furthermore, that Kerstin had chosen the same strategy as the teacher later hinted to some students (i.e. to search for answers in shaded text boxes, see p. 10).

Figure 6: Karin’s answer

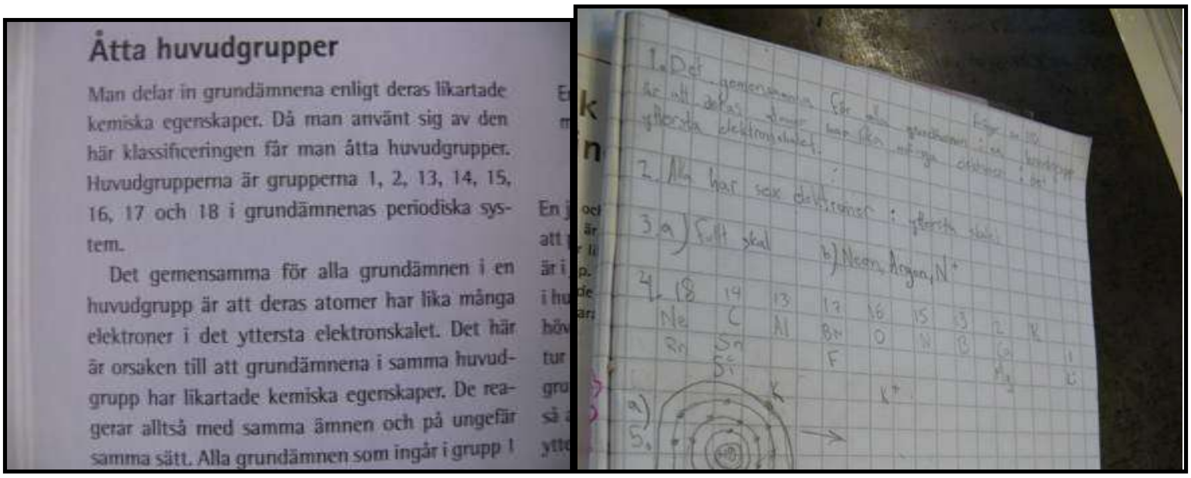
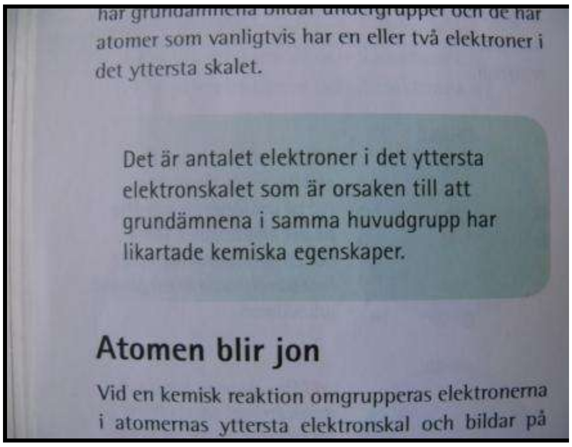


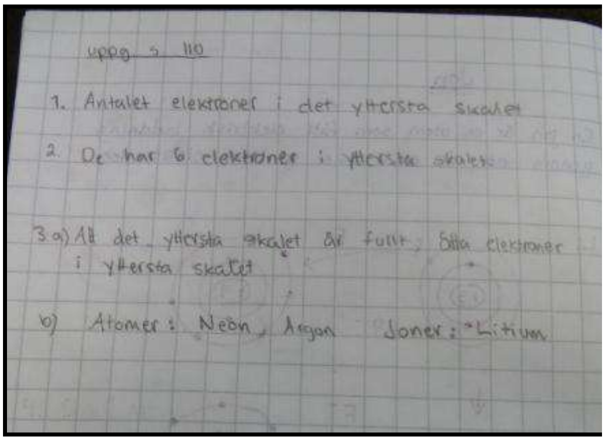
Figure 7: Kerstin’s answer


har grundämnena bildar undergrupper och de har atomer som vanligtvis har en eller två elektroner i det yttersta skalet.

Det är antalet elektroner i det yttersta elektronskalet som är orsaken till att grundämnena i samma huvudgrupp har likartade kemiska egenskaper.

Atomen blir jon

Vid en kemisk reaktion omgrupperas elektronerna i atomernas yttersta elektronskal och bildar på


uppg s 110

1. Antalet elektroner i det yttersta skalet

2. De har 6 elektroner i yttersta skalet

3 a) Att det yttersta skalet är fullt; fulla elektroner i yttersta skalet

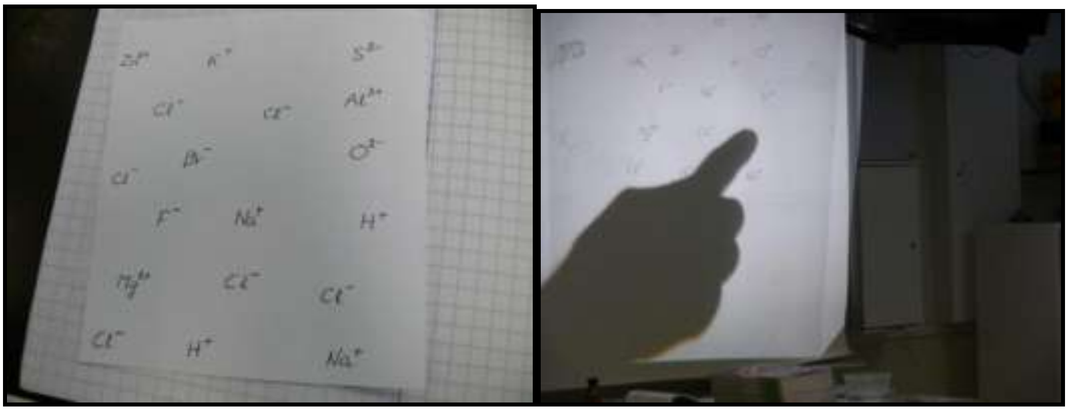
b) Atomer: Neon, Argon Joner: Litium

Both answers were reasonable, even though the wordings that Kerstin copied is a more direct answer to the question, while the wordings that Karin copied includes the gist of the task – although focusing on what the elements that belong to the same group have in common rather than why they react similarly. A reason why Karin had chosen to copy this sentence could be that the following sentence says “This is the reason why elements in the same group have similar chemical characteristics” – i.e. more or less exactly the same wordings as in the question, though phrased as a statement.

Worksheets

Another type of text that was present – though quite infrequently – in the classroom was worksheets of various kinds. During the second lesson in focus here, the teacher distributed a worksheet filled with the chemical symbols of a number of ions, and the students were told to group the ions into possible ionic compounds. The work sheet only consisted of the chemical symbols with the electric charge of the ions (i.e. the names of the ions were not written out).

Figure 8: Worksheet pasted into student’s notebook and on overhead projection



The preparation of this homework was relatively long (five minutes) and was delivered as a monologue by the teacher. When giving instructions, the sheet was projected and the teacher began by stating that they were going to “look at the overhead”. He then pointed at some positive ions, commenting on the electric charge. By combining what the teacher said with his pointing the students could draw the conclusion that positive ions are marked with a plus-sign – combined, if needed, with a figure:

> Teacher: I found a whole lot of ions and these were zinc ((points)) which has the charge plus two and then I have aluminium ((points)) which has the charge plus three and moreover I have a hydrogen ion here ((points)) plus one . magnesium ((point)) plus two and sodium ((points)) plus one and one more hydrogen ion ((points)) (Lesson 8, Sep 2007)

When continuing with the negative ions he did not comment on them being negative, but only pointed at them saying what they were called. In this case he was less clear about what a minus sign stands for, and instead this was implied. After that the teacher told the students that the ions were supposed to be combined into ionic compounds:

> Teacher: there is an optimal way of combining these so that they can all be in the game . thus you can make ion compounds from these in a way so that no one will be left . I can give you a couple of examples . you can take sodium and chloride ((points)) plus one and minus one and you (x) sodium chloride NaCl . you write it without those ((points at the plus and minus signs))
>
> (Lesson 8, Sep 2007)

Thus, the teacher mentioned that the students were not supposed to write out the electric charge for the ionic bonds but why this is so was not explained.

Labels and other texts on vessels

An important text in a chemistry classroom is of course various kinds of labels on jars containing chemicals, and naturally that text type was present around most experimental work. It is worth noting that in this Finland-Swedish classroom labels were written in Swedish or Finnish or both languages. Sometimes vessels lacked labelling.

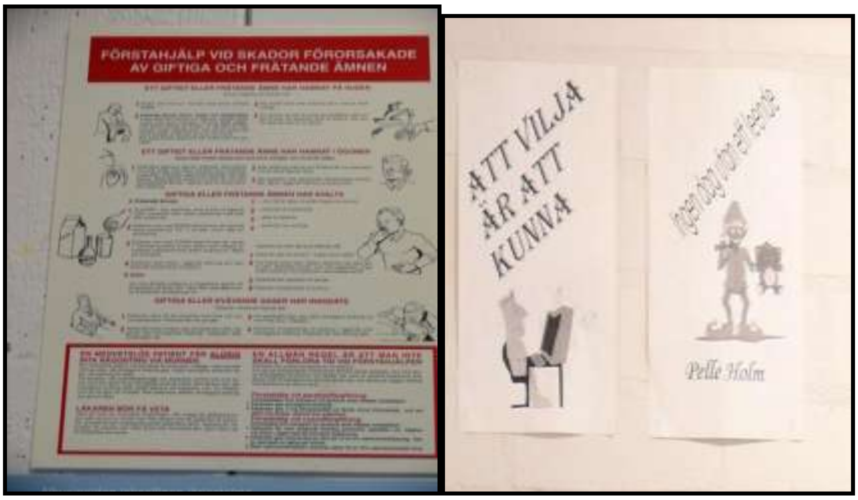
Figure 9: Finnish and Swedish texts on jars with chemicals

The teacher told the students to read the labels, but they were never expected to depend only on that information, since he usually distributed the chemical substances and then expected the students to keep them in order. Once in a while students asked for a translation of a Finnish word on a label, but it was also common that the students did not seem to read the labels at all. Of course it is difficult to determine whether they actually read the labels from looking at photographs and video recordings, but it was quite unusual that they seemed to read more than the actual name of the substance. Some labels contain a lot of information, for instance the jar filled with lead, whose label contained both a long (Finnish) text and a warning symbol. Neither the teacher nor any student commented on what kind of information that was or whether it was important in any way, even though both the teacher and students at some occasions brought up how dangerous some substances are and what might happen if you by mistake swallowed some of it. However, these conversations were never linked to the actual information available on the containers.

Texts on the classroom walls

There were also various kinds of texts on the classroom walls, both with information linked to the subject (e.g. what cupboards contain, instructions about what to do in case of an accident etc.) and texts of more general nature, like words of wisdom etc.

Figure 10: Informative text and words of wisdoms on walls



These texts were never brought to the fore in classroom practice. It is possible these informative texts had been discussed when chemistry lessons began the previous year, but no such conversation went on during the period we visited the class.

Students' private texts

Apart from the texts described above, some private texts were present in the classroom (only calendars in which the students noted their homework). In this school mobile phones were prohibited and no private text use via electronic devices was seen.

Discussion

In the introduction, I discussed the possibilities of discerning various semiotic resources and text types used to shape and represent knowledge by using a multimodal perspective (e.g. Jewitt & Kress 2003, Kress 2003, 2010, Selander & Rostvall 2008) and an extended concept of text (e.g. Kress & van Leeuwen 2001) in the analyses. The survey of literacy events in this classroom revealed that various types of texts came into use, like textbook text, notes on the blackboard (such as chemical formulas, and drawings of artefacts), labels on vessels, students' notes, etc. Thus, students in this classroom must handle a variety of text resources in different ways. Some are more dominant in the classroom than others – notably the screen with the periodic chart and the teacher's notes on the blackboard, copied by the students into their note books. However, no digital texts (TV-programs, DVD's, Internet texts, etc.) were used, which is a bit surprising, considering the extent to which such resources nowadays are more or less taken for granted (Bezemer & Kress 2008, Jewitt 2005). In an interview, the teacher commented on this, saying that he sometimes used Internet or texts from other media, such as newspapers, when working with content areas other than this, but he claimed that there is a lack of useful texts dealing with this particular content area.

A number of lesson activities recurred in this classroom, such as a follow-up of homework, overviews of new theoretic content, experimental work (including preparation and follow-up), and, at times, the introduction of new homework tasks. All activities, except experimental work, were delivered in the form of a teacher monologue, while students only gave short answers to direct questions posed by the teacher (cf. Mehan's, 1979, description of classroom communication in terms of *initiative, response, evaluation*, IRE). Texts normally came to use during introductions of new theoretical content, during run-throughs of given homework (and at this particular occasion also in connection to instruction of the next week's homework), and finally in connection to instructions about experimental work and run-throughs after these. In all these cases, the text use consisted of teacher's notes on the blackboard (copied by students), but also his references to the screen with the periodic chart.

Apart from being in control of what texts were fore grounded and when, the teacher was also the main text producer. The students did produce texts, but these were mainly copies of the teacher's notes on the blackboard, and no writing of longer texts (such as experimental reports etc.) took place in the classroom. In an interview, the teacher commented on experimental reports claiming that the students were not yet advanced enough to write such texts, since he regarded them too complex for students in secondary school. Furthermore, he viewed the production of them something that had to be done "haphazardly" since the students would have to solve the task on their own. Thus, a scaffolding situation (e.g. Gibbons 2002, Rose 2005) with joint text work – through which the students step by step integrate new text types in their repertoire – did not seem to be a natural alternative.

Above, a number of frequent genres identified as typical of scientific discourse were noted. The writing activities in this classroom did not correspond to any of these, but they can be described as "stages" (Unsworth 2001) which form part of such genres. Examples include: lists (or direct depictions) of equipment needed for experimental work (can be part of *procedure*, used for instruction or reports in connection to experimental work), or lists of chemical formulas and symbols, etc. (can be part of *scientific explanation*). As regards reading, the same pattern can be discerned in cases when reading was connected to the teacher's notes on the blackboard.

However, when reading the textbook, the students of course came across longer texts with various genres and macro genres – for instance *scientific explanation* or *historical recount* (*historical recount*, i.e. events retold in a sequence, might not usually be expected in scientific texts. However such texts do occur in textbooks; in this particular one, they are found on pages marked “Extra”, i.e. pages considered less important).

No activities focusing reading strategies etc. were integrated into the classroom activities, instead the teacher expected students to learn the subject partly by independent reading. This observation is similar to that of Digisi and Willett (1995). Also, even though the students in the present study very rarely read it, sections of the textbook were the only longer running texts the students came across in this classroom, just like in Edling’s study (2006). The scarcity of textbook use is surprising when regarding the study which Wikman (2009) refers to in his article (however, we do not know whether that study actually reveals that textbooks are used actively in classrooms or only that they are considered important in the Finnish school culture, which is certainly the case in this classroom). As was mentioned above, Ekvall and Berg (2010) found a number of potential obstacles both regarding structure and content in the textbook used in the classroom. The textbook is potentially difficult to use for the students, and quite heavy demands are therefore put on students reading on their own, both regarding their reading competence and their ability to select and understand the content, as well as coding the interplay between various modalities in the texts.

As regards metacommunication around text use, this was scarce. The teacher occasionally showed how to read the periodic chart, at least implicitly by using gestures and comments like “it is organised here ((pointing at the chart)) in a special way so that you can find /atoms/ with the same number of electrons in the outer shell” (p. 13). During writing on the blackboard, the activity was occasionally complemented with a meta-textual comment: “write “working with ions” as a heading /.../and then you can see what you have done later if you look for it” (p. 15). This comment clearly reveals that the teacher expected the students to copy the text word by word. A couple of occasional meta comments around drawing were also found, e.g. when the teacher drew test tubes on the blackboard or when he drew models of the atoms in connection to the run-through of the homework. When drawing the atom he altered between drawing atom shells without comments and asking students to be explicit about when a new shell is needed and what this is called. On the contrary, the teacher did not talk about how the shells should be drawn or why to draw clearly separated circles around a distinct nucleus (the various ways in which teachers and textbooks present e.g. the model of the atom, as well as students’ description of these in the interview situation is further elaborated in Danielsson submitted and 2010a). When the teacher drew test tubes in preparation of experimental work he said that he drew them slightly apart (but did not comment on why) and he pointed at the three test tubes to indicate that the students were supposed to note what the different solutions looked like (but he only wrote “what do I see” beside one of them).

The communication around text activities when working with questions in the textbook or around follow-up of homework was equivalent to that in Edling’s study (2006), with a teacher monologue introduction followed by students’ text work of a reproducing character. When writing answers to textbook questions during a lesson, no follow-up was done by the teacher. However, during the activity the teacher gave comments like “the answer can often be found in the shaded text boxes”, and on one occasion a student asked for help: “is the answer to 1a somewhere here?” (p. 10). The student’s question as well as the teacher’s response reveals an engagement at the surface level of the text, something which is quite common in schools (e.g. Nilsson 2002). Even though we cannot tell for sure that this is the case (e.g. Anward 2005), it is possible that an engagement at the surface level can lead to a situation in which the student is able to produce correct answers, but without having really grasped the content. The discussion between the two focus students that had copied different key sentences to answer a question could be a sign of this (p. 16f).

To sum up, there was no sign either of active text work around reading and writing of the kind advocated within SFL pedagogy (e.g. Fang & Schleppegrell 2009, Martin & Rose 2007, Rose 2005), or any joint reading similar to the model Questioning the Author (e.g. Beck & McKeown 2006, Reichenberg 2005). In that sense, we can conclude that there is an unutilized potential for working with the enculturation of the students into the written discourse of natural (school) science, for example when using the textbook to answer questions or during preparation and follow-up of homework as well as the situations when the teacher made notes on the blackboard. Whether this classroom is typical of chemistry classrooms, or even typical of Finland-Swedish chemistry classrooms, could of course be questioned. However, preliminary results from analyses of further data collected in a number of Finland-Swedish and Swedish classrooms within the project reveal a similar pattern (Danielsson in press), a pattern also similar to results from projects recently completed in Norway (Skjelbred & Aamotsbakken 2010, Løvland in press). However, as was stated at the beginning of this article, another way of going about this is by providing the students with a rich textual and linguistic environment, thus giving the students opportunities to develop their linguistic repertoires inductively. When it comes to writing, the students were given models through the teacher’s notes on the blackboard. Had the teacher chosen to leave to the students to formulate their own notes there could of course be a risk that they develop and consolidate ineffective text patterns. But as mentioned above, text work in the classroom consisted entirely of short lists and no longer running texts were neither written nor read. As regards the reading of longer texts the students were left on their own, since neither the textbook, nor any other longer texts were used actively in the classroom.

The limited extent to which meta-textual work went on in the classroom could perhaps be expected. The stance that text competence is an integrated aspect of content knowledge has not yet penetrated classroom practices, and many teachers in higher grades assume that the students’ reading competence is adequate for independent reading of textbooks (unless the student is considered to have learning difficulties). Furthermore, it is quite common that teachers have a simplified view of the reading and writing processes, assuming that reading and writing is something you learn once, and from that perspective anyone who “can read” is supposed to be able to handle various kinds of texts without any special support or guidance (see also e.g. Norris & Phillips 2003). The interview with the teacher revealed that he regarded the textbook as too verbose, something that in his opinion makes it difficult to read. Also he claimed that the content in itself is laden with “difficult words” that might require explanation. However, there is of course a big step from realising that a text might be difficult to read to including text focus in classroom practice. Moreover, we cannot expect teachers in subjects other than e.g. mother-tongue to regard themselves as developers of genre competencies among the students. So far this perspective has probably not been prioritised in teacher education, and we cannot take for granted that teachers in science should have a specific interest in linguistic issues or genres. If they themselves possess genre knowledge this is often a "silent knowledge" that has been acquired implicitly through encounters with texts within the content area. For this silent knowledge to be converted into an active focus on linguistic development within the school context (something that is clearly stated at least in the governing documents within the Swedish school system) further training for current teachers is required. This has to be done in order to provide teachers with metalinguistic knowledge as well as tools for how to work with the integration of language development approaches with content knowledge. For this purpose inspiration can be found within the SFL pedagogy as well as Questioning the Author approaches.

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Transcription key

/atoms/	transcription has been completed to make excerpt intelligible (e.g. a pronoun changed into its correlate, or slip of the tongue that was corrected later, if a too lengthy excerpt would be needed to make it intelligible)
...	pause (number of dots in pause indicating approximate length – each dot corresponding to appr. one second)
<u>look</u>	said with emphasis
”sodium in water”	speaker cites e.g. text
(xx)	approximate number of inaudible words
((points at chart))	meta comment about what speaker does
/…/	part of what is said is skipped
(no)	short comments etc. in someone else’s turn
yes?	pronounced with questioning intonation

Generally written forms are used and all names are always assumed. The transcriptions are approximate as well as the translations from Swedish to English.