Submitted to the Faculty of Educational Sciences at Linköping University in partial fulfilment of the requirements for the degree of Doctorate of Philosophy.

Studies in Science and Technology Education No. 8

Students’ participation in the realization of school science activities

Mattias Lundin

The Swedish National Graduate School in Science and Technology Education.

Linköping University, Norrköping, Department of Social and Welfare Studies, SE-601 74 NORRKÖPING, Sweden.
To Klara and Jacob
Abstract

This thesis investigates and considers how students and teachers realize school science activities. Students’ questions and accounts of their experiences as they become part of an established science content form the focus of this work. Its purpose is to provide an understanding of how two agendas – one, based on students’ participation and the other, based on the already established science content – are orchestrated so that both are accounted for. The empirical work is based on video-recorded observations in science classrooms. The findings show how different activities in the accomplishment of a school science project orchestrate students’ questions and accounts of experiences with the science content. The findings also show how the nature of science (NOS) is communicated as a by-product of instruction. In addition, different uses of questions for bridging science and everyday ways of communicating are shown in the results. The findings also indicate the different roles that students’ experiences acquire in a school science activity. These results should be seen as a step towards a definition of the nature of school science (NOSS). School science activities become intelligible if we consider them from a basis of their own purposes and prerequisites. The concept of NOSS is described to elicit such purposes and prerequisites as they become apparent in the activity.
Acknowledgements


Kalmar april 2007.

Mattias Lundin
List of Papers

Paper 1
Building a common platform on students’ participation. A descriptive study of a human biology school project.
Lundin, M. Accepted for publication in ‘Journal of Science Education and Technology’.

Paper 2
Meaning making of precision and procedures in school science
Lundin, M. Accepted for publication in ‘Canadian Journal of Science, Mathematics and Technology Education’ 2007, No 8(1).

Paper 3
Questions as a tool for bridging scientific and everyday language games
Lundin, M. Accepted for publication in ‘Cultural Studies of Science Education’. 2007, No 2(1).
The original publication is available at http://www.springerlink.com.

Paper 4
Experiences and their role in Science Education
Contents

1 Introduction ................................................................................................... 4
2 Agendas in school science activities ........................................................... 10
3 Meaning making in school science activities ........................................... 20
   3.1 Different kinds of meaning making .................................................. 20
   3.2 Transitions between different ways of meaning making .................... 21
4 Research perspective ................................................................................ 26
   4.1 Language games in school science settings ...................................... 26
   4.2 The concept of experience ................................................................ 34
   4.3 Studying language games ................................................................. 37
   4.4 Theoretical choices in consideration ................................................. 39
5 Research questions .................................................................................... 44
6 The empirical study .................................................................................... 46
   6.1 General approach to data collection ............................................... 46
   6.2 Researcher’s role and attitude ......................................................... 47
   6.3 Comments on ethics ....................................................................... 48
   6.4 Settings for data collections ............................................................. 49
      6.4.1 Electricity class ........................................................................ 50
      6.4.2 Optics class ............................................................................ 50
      6.4.3 Human biology classes ........................................................... 51
   6.5 Transcribing ..................................................................................... 52
   6.6 To analyze language games ............................................................. 53
   6.7 Reflections on the chosen approach ................................................ 56
7 Presenting the articles ............................................................................... 58
   7.1 Building a common platform on students’ participation ................... 58
   7.2 Meaning making of precision and procedures in school science ...... 61
   7.3 Questions as a tool for bridging science and everyday language games.. 64
   7.4 Experiences and their role in science education ............................... 68
   7.5 Discriminating the nature of school science -conclusions ............... 71
8 Discussion ................................................................................................... 74
   8.1 Comments on the analytical approach ............................................. 74
   8.2 Discussion of findings ..................................................................... 75
9 References .................................................................................................. 84
Students’ participation in the realization of school science activities
Mattias Lundin
1 INTRODUCTION

It is not long since I worked as a science teacher in lower secondary school and I clearly remember when I “performed” my first science lesson in front of a class, its teacher and a teacher training supervisor from the university. In the reflecting talk afterwards, I especially remember the supervisor encouraging me in my teaching and adding that I had better avoid asking the students to guess what I was aiming at.

The lesson that he observed had dealt with density. My approach was to show different experiments to the students. In order to encourage students to participate, I asked them quite a few questions. Some of my questions were probably very difficult to answer for the students (maybe almost impossible to answer) because the students had limited experience of the phenomena I had showed to them. Nevertheless, many of my questions concerned their ideas that I wanted to include in the topic. My intention was to found the conversation on what they already knew. Consequently, my approach entailed questions of such a kind that the students had to guess what I was aiming at or guess what would happen next. It would be a lie to say that I had come up with the approach of asking questions to promote students’ activity myself. Of course, it was my idea to use the approach although I may have learnt the approach when participating in school science activities as a student myself.

My performance in that classroom included a feature of a traditional way of acting as a teacher. I do not mean to say that teachers generally ask many questions in order to promote attention, as I did. Nevertheless, I had learnt one way of carrying out science teaching in compulsory school by using questions. It is possible I may have picked up this way of acting from my own school teachers when participating in their classes. At the time when my teacher-training supervisor visited, I was trying to act according to what I considered purposeful in the teaching I had experienced as a student. Similarly, it is likely that my previous teachers had picked up features from their teachers by participating as students during their lessons.

What I have just mentioned is not more than a personal image of my attempt to create a science activity. It only brings about one feature of school science as well as showing only my experience. There were, of course, many other features of school science activities that I experienced. For example, during my teacher training I began to realize that students’ interests were something important. I also learnt to value other features of school science activities as important for students’ learning processes, such as experiments and support for
Students’ participation in the realization of school science activities
Mattias Lundin

students’ activity and their own research. As a newly examined teacher, in front of a class of my own, there were additional features to keep in mind. I remember for instance a certain anxiety in not completing the science course in due time and not living up to safety demands in the laboratory.

Although the consideration of safety and the accomplishment of the science course were important parts of my work, I would also like to stress the work in simultaneously considering the science course and its established content while involving students’ questions in the activity. I remember that I regarded my task as maintaining students’ attention, achieving curricular aims as well as considering students’ previous experiences, interests and safety in the classroom – all within the scope of one lesson. However, when trying to accomplish what could be described as an ideal state of things, I experienced a great deal of difficulty.

The features of school science that I now have exemplified, hint at a complex activity that builds on many different aims, such as the consideration of students’ interests and experiences as well as acting to make students active. Driver and Oldham (1986) present a constructivist teaching sequence in which “elicitation of ideas” is part. To make students’ ideas explicit, which is to bring “them to conscious awareness” (ibid., p. 118), constitute their explanation of the elicitation of ideas. My interpretation is that the elicitation that Driver and Oldham refer to corresponds to the consideration of students’ experiences that I have already mentioned.

There are also aims that stress a particular science content or certain methods related to the school science subject. These seem to be well established in policy documents and therefore I regard them as interesting. For example, in the Swedish curriculum of 1980 (Skolöverstyrelsen, 1980) students’ work to look for answers to their own questions and the importance of letting them formulate problems in order to stimulate learning are emphasized. It is also pointed out that students’ activity is an important feature of education, for example, as students are to learn how to identify problems and give suggestions for their solutions. According to the present Swedish curriculum Lpo 94 (Utbildningsdepartementet, 1994), we can see the teacher is supposed to take every individual’s needs, prerequisites and thoughts into account. Lpo 94 also states that students shall have influence on how to learn and what to learn. In making a quick summary of these curricula I would like to stress their emphasis on students’ activity and curiosity/interests, sometimes communicated in phrases like “students’ own questions”. At the same time as these curricula emphasize, for example, students interests they also state learning goals. For example, Lpo94 describes goals that are divided to three categories: 1)“nature and Man”, 2)“scientific activity” and the 3)“use of knowledge”. The
complexity makes school science a challenge. This is where I start, looking at an activity with which have only a little acquaintance so far but which seems so complex and interesting.

**Research interest**

This thesis focuses on how teachers and students realize school science activities. In his later writings, Wittgenstein describes how our language is used by reminding us of distinguishing features of its use (Stenlund, 1999). Wittgenstein (1953, § 89) defines what he calls a logical investigation. With such investigations we do not seek to learn anything new, he claims: “We want to understand something that is already in plain view. For this is what we seem in some sense not to understand.” Similarly, my idea is to elicit crucial and distinguishing features of school science activities.

In the last few years, school science activities have gained attention in research literature. The importance of science in school, students’ interests as well as their attitudes to the subject has been addressed. For example, school science has been described as important from a democratic perspective (Kolstø, 2003). Kolstø points out three changes in society that have impact on the relevance of science education. First, he points out that science comes with possibilities as well as risks and that knowledge is required in order for us to make responsible decisions and avoid risks. Second, he elicits how scientific discussions on the front-line of research can be mixed up with relativistic ideas and by such means lose reliability. Understanding of science methods is consequently important. Third, Kolstø elicits that a great deal of science research is done outside the universities, which give rise to the question of whether its results are biased. Students need to be prepared to take a critical attitude (ibid.). In order to successfully improve science education, to match, for example, the changes in society that Kolstø refers to, I argue that further knowledge about how school science is realized is needed.

Lindahl (2003) describes what reasons students in compulsory school have for not choosing further studies in science. She argues that students do not understand the way science is taught. Students have difficulty in understanding the meaning of classroom learning and laboratory work, Lindahl claims, and points out variation in teaching as one important remedy. An illustration of research that addresses students’ attitudes towards science is presented by Schreiner (2006). According to her, students prefer the extraordinary and the fascinating. For example, students are interested in “enigmas and phenomena which science still cannot explain, such as dinosaurs, the origin of life and mysteries in outer space” (ibid., p. 12). School science rhetoric about students’ interests has on the other hand presupposed that students are interested in issues that are close to them. Home chemico-technical products and other everyday
applications of science are such examples (cf. Lgr 80, Skolöverstyrelsen, 1980). According to Schreiner, students are not very interested in those topics. Schreiner (2006, p. 12) writes that “general everyday matters such as detergents and soaps, plants in the local area and how food is produced and conserved” are the least interesting topics to the students. Furthermore, students’ own questions do not necessarily fit with the prescribed content of science in the policy documents. Potential tensions between a prescribed content and students’ own questions make a teacher’s work a highly skilled and complex task. The complexities make school science activities a fascinating research object.

If actors on the science education field are well informed about the realization of school science activities, further improvements can be accomplished by cooperation between teachers, teacher educators and researchers. This point of departure implies studying school science activity as it is. My idea is not to study activities from a normative perspective. This thesis should be seen as an elicitation of school science as it is carried out the setting of the classes which were studied. That is, the observed classes have their prerequisites, resources, shortcomings, possibilities whereas other classes have theirs. My intention is to elicit parts of an activity that can become relevant and useful. This far I have hinted at school science activities as complex, where students’ interests and questions need to be considered as well as the subject content.

This project sets out to examine how school science activities are realized in compulsory school. When using the word ‘realize’ I refer to the same concept as the Cambridge international dictionary of English: “To realize something is to cause it to be real or to exist or happen in fact” (Procter, 1995, p. 1180). The role of students’ questions and accounts of experiences, given in, for example, suggestions, is focussed. However, school science is not only based on these ideas. School science also involves a curriculum and traditions when it comes to the choice of content and prevalent ways of communicating that content. When school science activities are realized the ideas that the students communicate may need to be orchestrated with those of school science. The purpose of this project is to provide understanding of how such components are orchestrated in the realization of school science activities. Further information on the research purpose is given in Chapter 5.

In the analysis of school science activities, illustrative examples are needed. When showing such examples of how school science activities are realized and pointing out distinguishing features, an important issue is not to become judgemental. From my point of view, school life involves a great number of things to consider. Being a researcher is being an outsider who may easily criticize approaches without taking all the other “parameters” into account such
as, workload, pressure from parents and so on. My position is to point out states of things. I regard this as an ambition to take participants’ perspectives. The elicited features of the realization should be seen as conceivably relevant in other settings.

Before turning to the next chapter, in which I focus on research that deals with agendas in school science, I briefly intend to present the main parts of the thesis. As already mentioned, the focus of the next chapter (Chapter 1) is on different agendas that are part of school science activities. In Chapter 2, I turn to ways of meaning making that have been found in school science. Chapter 4 gives the theoretical foundation for the thesis and attaches the concept of meaning making used in Chapter 3. In Chapter 5 the research questions are given and in the subsequent chapter (Chapter 6) the empirical work is presented with comments on the analysis. The four articles that are attached to the thesis are summarized in Chapter 7, along with conclusions. The last part is numbered 8 and it consists of a discussion of my findings.
Students’ participation in the realization of school science activities
Mattias Lundin
2 AGENDAS IN SCHOOL SCIENCE ACTIVITIES

This chapter is intended to exemplify different concerns, goals, projects, issues and undertakings that build school science activities. I have chosen to name these ‘agendas’. Of course the word ‘agenda’ is not used to mean any concrete list of items but various things that become relevant in the realization of the activity. The nature of science is a concept providing ideas that are relevant to science education and school science activities. In the first part of the chapter I introduce the nature of science (NOS). In the subsequent part I exemplify agendas by referring to the NOS. After that I focus on pedagogic ideas and use these to exemplify other agendas. In the last two parts, tensions between different agendas are addressed and methods of how these can be orchestrated.

The nature of science

The NOS is a central concept of my thesis and the next paragraphs are used to briefly introduce the concept. Research concerning the NOS point out its relevance for school teaching to some extent. However, there is an absence of consensus regarding what the NOS is (Driver, Leach, Millar & Scott, 1996; Smith & Schermann, 1999). Driver et al question the possibility of assessing a person’s understanding about the NOS. According to them, such an assessment presupposes agreement of what the subject really is, which is the case with natural phenomena but hardly the NOS. Nevertheless, Khishfe and Abd-El-Khalick (2002) use the concept NOS, which they describe in four statements that they claim are not controversial. These are: 1) Scientific knowledge is subject to change, and can be described as tentative. 2) Scientific knowledge is based on empirical observations. 3) Scientific knowledge is a product of human imagination and creativity. Their last statement is: 4) Science knowledge is made with a distinction between observation and inference. That is, observations are accessible to our senses but an inference is not. The latter is logical and based on observation instead. Questionnaires have been used to address students’ (cf. Khishfe & Abd-El-Khalick, 2002; Driver et al, 1996) as well as teachers’ (cf. Abd-El-Khalick & Akerson, 2004; Wallace & Kang, 2004) views of the NOS. Research has also focused on disagreements about the NOS (cf. Smith & Schermann, 1999). Nevertheless, the four statements (Khishfe & Abd-El-Khalick, 2002) provide a possible agenda in the realization of school science that deals with giving an appropriate view of science. That is, for example, to show to students that science is based on empirical observations.

Schwab (1978) suggests three skills that help us discriminate agendas in school science activities. The first skill is the application of truths that are learned from the discipline. Second is the skill of inquiry. The third skill that Schwab points out deals with interpreting the meanings that are embedded in the disciplinary
setting. The empirical nature of science and the repeatability of experiments are meanings that previously were related to the NOS and this can be seen as Schwab’s third skill. Schwab’s (ibid.) separation of skills connects to Schwartz’ et al (2004) claim that “doing science” is insufficient for developing understanding of the NOS, as the learning object refers to different skills. Classroom research could examine whether, for example, the ideas regarding the NOS are non-controversial in the school science setting and what impact on the activity they might have. By studying the realization of school science activities, such features may become elicited.

Teacher’s views of the NOS are important for how the NOS is staged in a school science activity. Munby, Cunningham and Lock (2000) present a case study of one teacher’s teaching in which three characterizations of school science are presented:

- “Science is fun and activity-oriented” (ibid., p. 205), that is, activity for fun rather than activity for learning
- Science as structure, facts, technique and precision
- Science is experimenting, trying, doing and finding out

Munby et al (2000, p. 208) conclude that,

> “when science is removed from contexts that match and support its goals of inquiry and experiment, its character can change. School science is distinct from experimental science because it is practiced in an institution whose goals are not the goals of science, and so school science becomes an inauthentic representation of experimental science.”

The findings that Munby et al present are mainly based on interviews and do not provide details regarding how the characterizations of school science (see above) are accomplished in classroom praxis. Nevertheless, the three characterizations are possible agendas for science teachers to follow.

Before turning to how the NOS is staged in school science activities, I will briefly illustrate what have been said about students’ views of the NOS. Hogan (2000) refers to two categories for classifying students’ understandings of the NOS. First, students’ knowledge about the practices and processes of the professional scientific community is called distal knowledge about the NOS. Second; proximal knowledge of the NOS refers to students’ understandings of their own science knowledge-building practices. Hogan argues the importance of distinguishing these two, because “these types of knowledge structures might have different impacts on students’ learning …” (ibid., p. 54). Hogan’s’ categories relate to the agendas that are focused here. For example, an agenda including information about professional science practices implies focusing
distal knowledge about the NOS. However, the description of Hogan’s two categories comprises metacognitive epistemological knowledge. That is, his explanation of the concept does not concern the way the NOS is enacted in school science.

**The NOS and the school science setting**

In this section I present research that contribute to an image of the NOS in school science. I begin with images of science that are given in school science and end with pictures of science that research has pointed out as problematic. It has been pointed out that in order to better understand science in schools, research should include analyses of, for example, social processes that account for how science is presented and accomplished (Kelly, Chen & Crawford, 1998). For example, the NOS can be interpreted by ethnographic methodologies, they argue. Rowell (1996) examines images of science, as these are portrayed in genre-based classroom materials, and she concludes four messages in these materials. First, school science entails learning how scientists order and classify information. Second, school science entails a technical vocabulary. Third, learning to read and write the special forms is a key to learning school science. The scientific report is one example of such a special form. Fourth, school science entails learning how to do “scientific” experiments. I regard these messages as a by-product of the classroom materials and I argue the importance of studying if similar messages can be found in school science talk and school science activities. Nevertheless, from Rowell’s research an agenda writing scientific reports (for example, laboratory reports) and performing “scientific” experiments can be asserted.

Criticism concerning the nature of school science has been presented. Bencze (2001) uses various research reports for criticizing science education and arguing “‘technoscience’ education” instead. For example, he argues that school science develops confused conceptions of the products of science, idealized conceptions about the nature of science and that “students rarely have opportunities to do science in school science” (ibid., p. 275). Consequently, the purpose of Bencze is not to analyze the nature of school science but to introduce ‘technoscience’ education. Nevertheless, Bartholomew, Osborne and Ratcliffe (2004) report from fieldwork where teachers were asked to teach aspects of science. They studied how the teachers taught about science by looking at how they addressed different themes of the NOS. These themes concerned, for example, scientific methods and critical testing, science and certainty as well as hypothesis and prediction, just to mention three of them. The teachers were asked to address as many of the themes as they felt able to. These themes then constituted agendas in the teacher’s science teaching. For example, they might have addressed an agenda for elucidating scientific methods and critical testing. Bartholomew et al conclude, “teachers need
considerable assistance and training to relinquish the IRE dialogue—a discourse which is an inevitable reflection of the dogmatic nature of school science” (ibid., p. 679). The findings that Bartholomew et al present are based on a particular approach to the NOS (the studied teachers based their classroom activities on the researchers’ themes). That is, they used the themes for an intervention study rather than studying classroom activities making minimal intervention. Contrary to their approach, the purpose of the research presented here studies classroom activities using minimal intervention.

Even though the NOS is not addressed specifically, as in the research of Bartholomew et al (2004), ideas about the NOS can be provided. School science sometimes even gives false ideas about science and research (Allchin, 2003). There are myths originating in historical narratives of scientific discovery. Scientists are sometimes described as heroic characters without flaws. Furthermore, Allchin claims that these historical narratives often tell an idealized story where issues are simplified and the storyline is sharpened to make a good plot. An agenda stressing the need for an interesting plot seem to overshadow what view of the NOS is given. The reasons for idealizing the story are not brought out in Allchin’s presentation. Nevertheless, it is reasonable to argue that there are reasons for making a good plot and that a tension between presenting an accurate story and making a good plot can be seen.

Allchin presents further characteristic features of these mythic narratives. Opportunities for research are, for example, interpreted as geniality and uncertainties as universality in the narratives. McComas (1996) points out students’ and many of their teachers’ myths about scientific activities and suggests ten such myths. Here, I will pay attention to four of those that relate to scientific inquiry. The fist one he calls “a hypothesis is an Educated Guess”. This definition is very common in a science class, McComas claims and argues that the word ‘hypothesis’ also can be used to mean an immature theory. In school, he continues, the word ‘hypothesis’ can be used to mean forecast. The second myth is the idea of a general and universal scientific method. Usually the idea of such a method includes steps to a) define the problem, b) gather background information, c) form a hypothesis, d) make observations, e) test the hypothesis and f) draw conclusions. The idea of a universal scientific method is in line with the myth that science is procedural more than creative. McComas maintains that school science does provide step-by-step manuals that mediate the idea that science is procedural. The fourth myth that I would like to elicit from McComas brings out that “experiments are the principle route to scientific knowledge” (ibid., p. 5). These myths, he claims, are encouraged with all the hands-on tasks realized in science classroom. However, true experiments are different, McComas continues, as they often aim at finding causal relationships.
The myths that McComas (1996) describes cannot be seen as agendas of school science. Nevertheless, they are described as distinctive parts of school science and as such they are important information when we are to understand the agendas of science classroom activities. For example, by using the six methodological steps a teacher might provide clear instructions to students, which I regard as a possible agenda in school science.

Tobin and McRobbie (1997) focus on the realization of science education in a similar respect as the above mentioned. Their findings show how a teacher described science as tentative and subject to change. However, the teacher’s realization of teaching showed something different. In the classroom, they noticed a presentation of memorizable, static facts that were described as certain. This may seem contradictory, but it is still intelligible because teachers need to take several agendas into account in their work. It is, for example, possible that the teacher’s agenda was not only to present a reasonable view of science but that students should achieve success in tests and examinations. The difference between what the teacher said and did can be seen in their work managing tensions when realizing the activity. Similarly, Abd-El-Khalick, Bell and Lederman (1998) show how teachers can be well acquainted with aspects of the NOS (definition of the NOS cf. Khisfe & Abd-El-Khalick, 2002) and still not include them in their teaching. The reasons given for these circumstances originate from other agendas associated with teaching. Khisfe and Abd-El-Khalick give classroom management, routine chores and lack of resources as suggestions for the teachers’ priority.

**Pedagogic ideas and the school science setting**

Previously, I used the NOS to illustrate agendas of school science. Here, other pedagogic ideas will be used to illuminate agendas. First, students’ activity performing laboratory work (practical work) is used to illustrate priorities that may provide agendas in school science. Second, ideas that concern students’ discoveries and problem solving are presented for the same purpose. I previously referred to what McComas (1996) describes as a myth of a universal scientific method, which includes six steps. The myth is encouraged by the hands-on tasks that are realized in science classroom. Such hands-on tasks can be seen as one way to make students active. This I consider as an agenda of school science.

The phrase ‘Learning by doing’ (Dewey, 1938/1998) is one example of a wording that might have had impact on emphasis on science teaching. ‘Learning by doing’ can refer to the creation of a frame for students’ reference, facilitating what could be called our (the student’s) understanding of an object.
I assume that amid all uncertainties there is one permanent frame of reference: namely, the organic connection between education and personal experience; or, that the new philosophy of education is committed to some kind of empirical and experimental philosophy (ibid., p. 12).

The phrase ‘learning by doing’ can hardly be interpreted to imply that activity means learning, at least not if we aim at learning a particular content. That is, we cannot take for granted that a student learns what is intended, it is not sure that the learner accepts the responsibility for the learning activities (Entwistle, 1970). However, physical activities that we participate in imply experiencing and an experience constitutes one potential frame for reference. According to Dewey (1938/1998) relating learning to experiencing implies a view of learning as something that occurs continuously in our lives. The previous wording of Dewey should not be understood in a way that implies a straight relation between experience and the learning of a particular subject content. Dewey especially stresses that an experience does not have to be educative. Nevertheless, the wording might have had impact on teaching, for example, seen in teachers’ prioritizing students’ practical work.

‘Students’ activity’ is a prestigious phrase in pedagogical rhetoric (Halldén, 1982). Halldén points at two reasons for increasing students’ activity in education. The fulfilment of curricular goals that call for activity constitutes a first reason for promoting students’ activity. Halldén’s second reason for promoting students’ activity is based on the idea that activity promotes motivation. When doing practical work, safety constitutes a crucial agenda. The sociologists Delamont, Beynon and Atkinson (1988) give an image of science education as they write about how school science was introduced in upper secondary school. In their text “In the beginning was the Bunsen”, school science is depicted as something dangerous, involving an activity much based on dangerous substances and very special items such as specific laboratory equipment and safety arrangements that can only be found within science practices. Not only the classroom environment could be interpreted as different and distinguishing, but also the school science activity. A school subject that deals with dangerous and special items and specific laboratory equipment with particular safety arrangement can easily be interpreted to build on strong traditions and well-established routines. Furthermore, Delamont et al (ibid.) mention characteristic laboratory procedures as an example of how school science can mediate science as something esoteric. My interpretation is that procedures, too, can be related to the safety agenda because procedures and routines imply a consideration of safety.

To make students learn from their own discoveries is one example of an agenda of building classroom work on students’ activity. Such an agenda can be interpreted in approaches that accentuate classroom work that deal with
students’ discoveries of crucial scientific phenomena. Sugrue (1997) argues that learning by discovery is neither the best, nor the only valuable form of learning. There is in fact nothing that supports the idea that direct instruction would be less successful for developing understanding, she argues. Schwartz, Lederman and Crawford (2004) focus on scientific inquiry considering activities for developing scientific knowledge. In line with Sugrue they claim that engagement in scientific inquiry is not the one and only way. That is, just “doing science” is insufficient for developing understanding of the NOS, because it is possible to participate in a science activity without understanding the NOS. To learn the NOS, it is necessary to step outside science practice and consider it from an outside perspective, they argue.

Bergqvist (1990) points out other difficulties related to activities such as students’ laboratory work. For example, different meanings can be grasped from a school task. Her findings show a discrepancy in how the teacher made meaning of a task in contrast to how the students made meaning. Bergqvist explains that the teacher had access to a theoretical context when making meaning of the task, whereas the students had not. The students interpreted the task as a mere concrete activity. The discrepancy became evident, as students’ work did not match the learning that teacher had intended, Bergqvist claims. No matter what are the outcomes of discovery learning or scientific inquiry, such ideas are regarded as central pedagogical methods or agendas in school science activities.

In students’ problem solving activities their own initiatives are central. Planning, formulating questions to work with and keeping a critical attitude when searching for information are important parts of their activity (Kärrqvist, 2002). However, students’ problem solving is complex. Kärrqvist illustrates students’ limited interdependence on their sources and points to students’ search for information that was not guided by any question. Nevertheless, students’ social skills for performing the problem solving activity were satisfactory as well as the shape of the product. Kärrqvist points out that 60% of the observed groups of students (assessed by their teachers) worked without reflection (ibid., p. 273). Students’ problems solving seem to be another way of promoting student-activity. It is reasonable to suppose that students’ problem solving constitutes another agenda in school science.

### Tensions between agendas

Building education in concordance with, for example, the illustrated agendas does not necessarily imply any contradictions or difficulties. Nevertheless, tensions may occur between different agendas and I regard these tensions as natural features of education. Here, I will indicate some tensions that may occur between different agendas. For example, the syllabus of Lpo 94 (Skolverket,
Students’ participation in the realization of school science activities
Mattias Lundin

2000) specifies demands related to the science content. I regard these demands as one agenda for teachers. At the same time the teacher may acknowledge students’ interests as a second agenda. However, it is not to be taken for granted that the students’ interests correspond to the course plan. For example, tensions occur when students’ questions compete with goals related to the subject content. First, I illustrate a tension that refers to an emphasis on students’ responsibility for planning and working according to their own interests. After that I exemplify that a strong emphasis on experimental work can imply that a naïve picture of scientific work may be given.

A promotion of students’ own activity can be associated with approaches that involve students’ ideas and questions. Ideas to put the student and his/her first hand experience at the centre can be seen in many classroom studies. Dovemark (2004) interviewed teachers and school managers. She points out their assertion that students’ are responsible for their own learning. Her results also show that students in a similar way described their role to include responsibility for planning and learning. This approach is problematic. It is not easy for students to learn when to take the initiative, to plan and to know what to plan, and still accomplish the task in accordance with the teacher’s expectations (Bergqvist & Säljö, 2004). Consequently, these examples illustrate tensions between a pre-defined subject content vis-à-vis an agenda that promotes students’ own activity.

Similarly, Halldén (1982) writes about students that are to work with their own questions. He argues that it cannot be taken for granted that all students’ questions easily can be answered scientifically or that all questions are fruitful to work with scientifically. Halldén exemplifies with a girl, in upper secondary school, who expressed a fascination about continental plates and about how huge the dinosaurs were. If we look at her questions, the fascination of the size of the dinosaurs stands out as less relevant from a science education practice perspective (ibid.). That is, if education is built on students’ own choice of content, students’ own understandings define the potential subject content instead of the teacher’s broader insights (Carlgren, 1994). Then, the agenda concerning students’ questions and interests is prioritized. Halldén and Carlgren point out potential problems with student centred teaching.

Millar (1989) describes experiments as paradigmatic in school science because they show what it is to conduct a scientific investigation. Based on the claim that experiments are paradigmatic features of school science, I argue a teachers’ agenda involving experiments in their teaching. Millar explains that this feature of school science is rooted in history and the social context of school. Experiments are central in school science but so is second-hand data of the subject. Millar argues that these parts make up a difficult mix where a “naive
inductive and hypothetico-deductive view of science” (ibid., p. 58) stands out disproportionally. That is, Millar describes not only features of school science but also the complexity of its realization. If school science on one hand implies traditions and well-established routines and on the other hand consists of an disproportional employment of a naïve induction, it is reasonable to pay attention to how teachers prioritize different agendas.

**Orchestrating different agendas**

Given potential tensions between agendas in school science activities, I will now exemplify research that illuminates features of the realization of school science that orchestrate these tensions to an activity. I end this last part of the chapter by saying a few words about the participants’ different roles in the activity. The orchestration of agendas refers to the work to bring different agendas to a functioning activity. Then, separate agendas are prioritized in a way that is purposeful with regard to the circumstances. Consequently, the work to orchestrate implies prioritizing, for example, different goals associated with the separate agendas.

There is descriptive educational research that focuses on strategies for directing classroom conversations or ‘teachers’ techniques’ as Mercer (2004) describes them. Mercer explains that teachers may 1) elicit knowledge from a learner, 2) respond to a learner’s utterance or 3) describe significant aspects of a shared experience. A response can be a confirmation, repetition elaboration or even a reformulation. A description of a significant shared experience can be made as the word “we” is used and as the experience is recapitulated. Mercer’s techniques provide similar features as the pedagogical moves that Bellak *et al* (1966) describe. However, the latter relates to both teachers and students: 1) Structuring moves turn attention to the specific topic of a lesson. 2) Soliciting moves encourage people to attend to something. Bellack *et al* exemplifies questions, commands and requests to be soliciting moves. 3) Responding moves occur in combination with a soliciting move as they reply to those. Fourth and last, Bellack *et al* discuss 4) reacting moves. These serve the pedagogic aim to modify or rate a previous utterance. These moves are important for understanding how classroom conversations can be directed. The confirmations, repetitions, elaborations and reformulations that Mercer (2004) describes are similar to the responding and reacting moves Bellack *et al* (1966) argue. In my data these moves are relevant because they provide an opportunity for the teacher to orchestrate different agendas, for example, an orchestration of students’ questions (that is, one way to participate) and an established subject content.

Lidar, Lundqvist and Östman (2005) present moves that also can function to orchestrate, for example, students’ questions with an established subject
content. However, their focus is on how a *teacher* can direct students’ attention in science education. The first move of Lidar *et al* is called confirming. It deals with the teacher’s confirmation that the students recognize the right phenomenon. Second, a re-constructing move describes how the teacher can turn students’ attention to facts that were already noticed but regarded as less important. Third, an instructional move implies giving a concrete instruction for what to see or do. Fourth, in order to help students to explain an experiment, the teacher may summarize important facts of the experiment, which is making a generative move. The last and fifth move they call a re-orienting move. It implies pointing out properties worth investigating. The epistemological moves shows teachers’ different ways of turning focus to important phenomena. For example, they were used to turn focus to observations that are relevant from a science point of view (Lidar *et al*, 2005). The moves that Lidar *et al* describe refer specifically and only to what teachers do, which is not the case with the strategies Bellack *et al* (1966) describe. Nevertheless, the moves as well as the strategies constitute ways to pursue classroom work. In this context the strategies and moves are interesting as they provide a framework for studying the realization of school science activities and because they can be used to orchestrate different agendas.

A cultural activity (as I consider school science to be) is built of individuals’ actions in the shared setting, for example, a teacher’s consideration of a particular agenda. However, a teacher’s utterance is followed by a students’ response. Consequently, a teacher’s move needs to be considered in relation to the different contributions from the other participants of the activity and vice versa. Rogoff (1995) explains the dynamics of individuals’ contribution and the activity as follows:

> The use of activity or event as the unit of analysis—with active and dynamic contributions from individuals, their social partners, /…/—allows a reformulation of the relation between the individual and the social and cultural environments in which each is inherently involved in the others’ definition. None exists separately. (ibid., p. 140)

Interpersonal actions need to be considered as a part of the activity in which they take place. That is, the teacher’s moves are part of the school science activity and if a teacher’s move has impact on the activity the change might be reflected in a student’s subsequent utterance.
3 MEANING MAKING IN SCHOOL SCIENCE ACTIVITIES

The previous chapter dealt with agendas and the realization of school science activities. Here, I turn to different ways of meaning making in school science. In the first section of this chapter I will briefly present a few theoretical ideas concerning meaning making, although the presentation of my theoretical perspective comes later. The second section of the chapter deals with transitions between different ways of meaning making.

3.1 Different kinds of meaning making

Here I illustrate different ways of regarding meaning making. I introduce the topic by giving a few examples before I place focus on different kinds of meaning making that relate to the cultural setting in which meaning is made.

Lemke (1999) shows two ways of meaning making that he calls typological and topological meaning. Typological meaning refers to categorical meanings and discrete terminology, whereas topological meaning refers to a continuous variation and nonexclusive features. Categorisation of species is an example of typological meaning making, whereas topological meaning making is referred to as a fine description of parts of the brain that are without distinct borders. According to Lemke, typological meaning is privileged in our language. Nevertheless, an emphasis on typological meaning limits our view of the world, he argues. Minick (1996) gives another example when he exemplifies how we use representational meaning making on some occasions and non-representational meaning making on others. Representational meaning making implies that meaning is made literally. Non-representational meaning making presupposes considering the context of the utterance. In science settings, such as school science, we learn when to make non-representational meaning. There is no direct relationship between a setting and how meaning is made. However, semantic relationships are constructed between utterances in a conversation. Lemke (1990) describes how these relationships are joined together in a thematic pattern. If the pattern is similar to what could be found in, for example, science textbooks, the conversation implies “talking science”, Lemke argues (ibid., p. 149). Consequently, the thematic pattern constitutes a framework that provides support for meaning making.

A thematic pattern that precedes an utterance is not always needed to know how to make meaning of it. I will now present another framework for meaning making. School science involves participating in a special activity of certain prevalent actions; in this case the activity is associated with science learning.
Participating in such an activity is to participate in a community of practice. Wenger (1998) claims that a practice can be seen as a community to which you learn to belong. A community is built of “mutual engagement, joint enterprise, and a shared repertoire of ways of doing things” (ibid., p. 49). Experiments (cf. Millar, 1989) are one feature of science education and they are part of the school science repertoire. School science activities can involve several thematic patterns (which more or less can attach to natural phenomena). However, a school science activity does not involve several communities of practice, rather, school science can be seen as one example of a community of practice. For the purpose of this thesis, theoretical ideas that elicit different aspects that can be found within school science activities are important. Szybek (2002) presents such a theoretical idea when he shows a dualistic feature of school science that is similar to thematic patterns. Szybek describes his idea in terms of a science stage and an everyday stage of events, which are based on different ways of meaning making about natural phenomena. The word ‘everyday’, as in everyday stage of events, is problematic. One person’s everyday life can be very different from another’s. Additionally, a considerable part of a student’s life takes place in school. Consequently, school constitutes a significant part of students’ everyday life. Szybek (ibid.) uses the everyday stage to discriminate the science stage of events. That is, the issue is not whether what is referred to as “everyday” really is part of a person’s everyday life, but to discriminate the everyday stage from the qualitatively different science stage. A similar assumption is made by Aikenhead (1997) who separates different ways of meaning making associated with subcultures in Northern America when he studied students’ science learning. His research interest deals with how students cross the cultural borders between such systems of meaning making. Aikenhead calls that border crossings. Although, Aikenhead refers to cultural borders that relates to ethnic groups, his lines of arguments are applicable to other kinds of cultures as well. The school science culture is such an example.

3.2 Transitions between different ways of meaning making

This section addresses transitions between different ways of meaning making. First, I refer to the previous paragraph where the science and the everyday stages of events were presented. I use these concepts to introduce what I mean with transitions. After that I present research to illustrate the impact of transitions on science classroom activities. Furthermore, school science involves translations between these stages. Szybek (2002) claims that school science involves bringing about everyday difficulties, referring to difficulties from various contexts of our everyday lives. The everyday difficulty can be translated to a scientific problem so that the problem can be solved on the
optional: Students’ participation in the realization of school science activities
Mattias Lundin

science stage of events. Szybek’s point is that the scientific solution then ought to be re-translated to the origin of the difficulty, that is to say, to the everyday stage of events. To deal with two stages simultaneously is a characteristic feature of school science (ibid.). Similarly, Schoultz (2000) points out difficulties in meaning making that we may come across when managing several different ways of referring to a phenomenon. From my point of view, a transition between different ways of meaning making might then be needed (cf. the translation that Szybek asks for). Aikenhead and Jegede (1999) claim that students in non-Western cultures may construct parallel concepts for phenomena in nature. From their point of view, effectiveness in students’ border crossings between everyday life and school science is a key to successful learning. Similarly, Wistedt (1990) claims that students have everyday concepts that differ from the prevalent concepts in school. She argues that these alternate concepts are often difficult to manage in school and that they sometimes co-exist with valid concepts used in school.

Instead of talking about parallel concepts (Aikenhead & Jegede, 1999) or alternate concepts (Wistedt, 1990), Wyndhamn and Säljö (1997) refer to situated ways to communicate in different cultural practices. From their point of view, interaction in a group of peers provides a shared context, which facilitates students’ chances to grasp an appropriate way of communicating with each other.

Emanuelsson (2001) has identified two kinds of questions that he calls vertical and horizontal questions. Vertical questions shift focus from particular pieces of information to general principles or explanatory models. Horizontal questions imply a shift of context as a question shifts from a scientific meaning making about a phenomenon to an everyday meaning making concerning, for example, an everyday application of the phenomenon. The latter shift I identify as a transition.

It is not necessarily easy to establish relations between experiences framed by essentially different situations, such as situations in everyday contexts and school science. It can, for example, be difficult for a student to perceive the science content in an everyday question (Schoultz, 2002), that is, such a question illustrates what Emanuelsson (2001) calls a horizontal question. Schoultz adds that this kind of question easily gets an everyday answer and he gives an example where a particular item (for example, a bicycle pump) is used to illustrate a scientific principle. Schoultz argues that there are no guarantees that a pupil perceives the connection between the everyday item and the scientific principle (compression of air). Consequently the pupils’ subsequent talk may deal with the construction of cycle pumps (or other details), instead of scientific principles. The difficulties in meaning making that Schoultz refers to
Students’ participation in the realization of school science activities
Mattias Lundin

and that are identified by Szybek (2002) illustrate transitions in school science and difficulties associated with these.

When bringing “everyday life” problems to science classroom, the context is inevitably transmuted (Andrée, 2005). Andrée argues that it is insufficient to describe “everyday life” in terms of, for example, border-crossings because what goes on in the science classroom is structured in relation to the activity system of schooling. Andrée shows how “everyday life” problems provide hypothetical problems without the original contextual support (cf. Bergqvist, 1990, p. 56, for a similar illustration). However, the example only shows how teachers’ everyday contextual problems are taken up in the classroom. Students’ ideas and questions, based on everyday experiences are, too, part of the realization of school science activities and these remain in focus of this research.

When considering, for example, students’ previous experiences, as in this thesis, these transitions are pertinent. Ogborn, Kress, Martin and McGillicuddy (1996) use the word transformation and they argue that transformations of scientific knowledge are not only made to fit into school, transformations are also made within school science. These transformations are combined with a difficulty that comes with teachers’ work. For example, science teachers sometimes need to explain things that might seem obvious from an everyday point of view, Ogborn et al (ibid.) conclude. Some students experience difficulty in using science ways to explain, because they are different from everyday ways of explanation. Szybek (2002) argues that if a need for remedy has been translated to a scientific problem and the problem has got its solution, a second translation is needed (cf. above). This second translation aims at creating a relation between the scientific solution and the corresponding need for remedy. When making the second translation, the teacher makes the scientific explanation relevant for the original need for remedy (ibid.). The translations between stages that Szybek discusses are similar to the transformations of knowledge that Ogborn et al (1996) identify.

There are prevalent ways of communicating and acting within school science (Östman, 2003). Consequently, there is a regularity of legitimate ways to explain science phenomena and transitions are not made in any direction in school science. From Dimenäs’ (2001) point of view, occasions when students’ everyday and science worlds meet constitute opportunities to integrate the understanding from outside school with that of science. However, I would like to point out that what Dimenäs says is based on the idea that there is an advantage if we have only one way of understanding phenomena. An alternative idea is that different ways of understanding can be purposeful in different settings. Säljö and Wyndhamn (1996) give an illustrative example
showing the impact of context on how we approach a problem. Their example shows how students solve an everyday problem differently in various classroom contexts. For example, students tend to determine the value of a postage stamp depending on the lesson in which they were given the task. During math’s class a majority of students calculated the value, whereas it was estimated during social science class (ibid.).

Previous research that touches upon the idea of transitions has been presented. Research has, for example, focussed on how students move between everyday and science ways of referring to the world. I intend to develop theoretical ideas that deal with such transitions in the next chapter, which deals with my research perspective.
Students’ participation in the realization of school science activities
Mattias Lundin
4 RESEARCH PERSPECTIVE

In the previous chapter I briefly explained a few theoretical considerations in order to be able to present research showing how school science consists of different ways to act and interact. I will now present theoretical ideas that provide a foundation for a subsequent construction of a research method. The choices of theory need to facilitate a study of how different actions make up the realization of school science. The research perspective is chosen in order to enable understanding of how meaning is made of words (and actions). Furthermore, previous experiences are another feature that the research perspective needs to explain. Consequently, in this chapter I will first develop the concepts of ‘language game’ and ‘experience’. After that I point out some issues regarding the study of language games. In the last part of the chapter, the theoretical choices are considered.

4.1 Language games in school science settings

The concept of ‘language games’ will here be developed in the following way: firstly, I define the concept; secondly, I focus on meaning; and thirdly, I focus on companion meaning. The last two are central aspects of language games. The fourth and fifth parts of this section deal with how to address differences between settings (for example, school science settings) and what kind of practice school science could be regarded as.

Participating in a language game

In order to explain ‘language game’ I refer to ‘communities of practice’ and ‘stages of events’. After that I end this part by explaining what rules of a language game are implied in this thesis. In the previous chapter I illustrated that school science comprises different ways of meaning making. I used Wenger’s (1998) ideas to explain that communities of practice are united with, for example, specific ways of meaning making and repertoires of doing things. ‘Language game’ is a concept with resemblances to ‘community of practice’. The resemblance that is the most relevant for this thesis concerns meaning making. I have already pointed out that I regard school science as one community of practice, and not several. Nevertheless, school science comprises different ways of meaning making. In this thesis meaning making will be used as a concept that makes it possible to discriminate different language games within school science.

A language game is identified by the ways we speak and the ways we act (Wittgenstein, 1953, § 7). Wittgenstein uses the word language game to
emphasise that “the speaking of language is part of an activity, or of a form of life” (1953, § 23). That is, participating in an activity involves acting according to rules concerning how to make meaning in that particular activity. A language game thereby also refers to discursive rules for how to use words in a particular setting (cf. Östman, 1998, p. 57).

In school science we can identify an everyday and a science stage of events (cf. Szybek, 2002 in the previous chapter). In this thesis everyday and science language games are the relevant concepts. When I use the concept everyday language game, I refer to students’ everyday school language game that differs from scientific meaning making (during science lessons). Nevertheless, the question is what distinguishes an everyday language game from a science language game. A science language game (in a strict sense) is not likely to be found in a school science context. Yet, it is likely that we find science ways of meaning making in school science. If a student relates a previous experience, he or she might make meaning in a way that is prevalent in school (in general) or in a way that relates to the settings of the original experience. However, a plausible purpose with science education is to prepare pupils to participate in conversations about scientific issues and make scientific meanings of words.

A language game does not comprise a set of opinions about, for example, natural phenomena. Language games are seen in the different ways of meaning making. Similarly, Wittgenstein’s use of language games does not involve the participants in sharing opinions, only that their ways of acting are similar (Svensson, 1992). That is, language games are mutual engagement in activity, in this case an activity that deals with natural phenomena and scientific ways of meaning making about them. Wittgenstein (1953, § 241) points out that we agree in the language we use and that is what makes the language game stand out. Harré and Gillett (1994) discuss narrative conventions, which they claim are similar to the grammatical rules of the mother tongue. Similarly, I refer to rules of the language game. However, it is not that you first learn the rules and then act according to them. Rather, you learn to participate, and from that you become able to discern rules and express them (ibid.). Bakhtin (1986) argues that learning the form of a language, such as its grammatical structure, is only one part of language learning. We also learn how to make mandatory utterances, Bakhtin claims. They are called speech genres and, according to Bakhtin, they are necessary for mutual understanding. Bakhtin’s speech genres are similar to the concept of language games as it is used here. For example, Bakhtin argues that speech acts have a normative significance and that these are given to us: “the single utterance, with all its individuality and creativity, can in no way be regarded as a completely free combination of forms of language” (ibid., p. 81). Similarly, we act according to the rules of a language game and
we might discern its rules as they have been given to us when we participated in the language game.

Anward (1983) gives four examples of rules for participating in a verbal activity. These rules deal with who can participate in the activity and under what circumstances. The rules also comprise which subjects and topics can be brought about as well as which words and phrases are meaningful to use. However, rules can change and it is indeed possible to break a rule although the consequence can be that your fellow participants no longer regard you as a participant in the activity. To illustrate -learning as belonging is an aspect of learning that brings out the mutual engagement, joint enterprise and a “shared repertoire of ways of doing things” (Wenger, 1998, p. 49). When focusing school science activity the NOS (cf. previous chapter and, for example, Khishfe & Abd-El-Khalick, 2002) provide an example of what can be included in such a repertoire. For example, empirical observations, making experiments, doing practical work and making predictions, constitutes possible features of mutual engagement and joint enterprise.

Bellack, Kliebard, Hyman and Smith (1966) interpret Wittgenstein’s concept of language game and claim that a language game is a metaphor for linguistic activities that “assume different forms and structures according to the functions they come to serve in different contexts” (ibid., p. 3). The joint enterprise and the shared repertoire of doing things, I regard as examples of the forms and structures that Bellack et al mention. However, the rules of a language game only exist in practice. The rules do not give cause; they are reconstructions after the event. Wittgenstein (1953, §31) relates language games to chess. He argues that the use of a piece in chess cannot be explained by the words “This is the king”, unless the person already knows all rules of the game, except what the king looks like. “The ostensive definition explains the use –the meaning– of the word when the overall role of the word in language is clear” (Wittgenstein, 1953, § 30). In other words, you have to know what you are about to give a name before you can ask for a word for it. That is, an item cannot have a name before it is found. In the above citation of Wittgenstein, he argues that an ostensive definition can be used to explain the meaning of a word. However, there is more to be said about meaning making and in the next paragraph I place focus on that.

Meaning making
I have already hinted in the previous chapter at different ways of meaning making in school science activities. Meaning making is a crucial concept for language games as well as for the thesis. Here I aim at giving a further explanation of the concept. What is expressed is done for a purpose and only in its application the expression becomes meaningful. That is, words are used for
a purpose and the actions need to be understood in relation to their consequences. Wittgenstein gives the following comment: “… A meaning of a word is a kind of employment of it. For it is what we learn when the word is incorporated into our language.” (Wittgenstein, 1969, § 61). Consequently, if a purpose of an utterance is to chat, expressions become intelligible due to that application. In another setting the words can be used for other applications and meaning is then made differently. For example, the meaning of “This room is really cold” may in its consequences be equal to “Please close the window”. That is, words themselves do not bear meaning without context. Meaning is in action and in the consequences of an action it becomes observable. This idea corresponds to what Roth (2005, p. 28) writes about the situational use of language:

“… we live in a world into which utterances are already inscribed; the situations we live every day and the words we use there make an integral part.”

That is, what can be seen as appropriate, right or wrong needs to be considered in relation to our purposes for talking. In conformity with Roth, I argue that language is an integral part of a situation in which we orient ourselves to projects we participate in. Wittgenstein (1953) summarizes this line of argument about words that are given meaning in application in the following way:

“Every sign by itself seems dead. What gives it life? –In use it is alive. Is life breathed into it there? Or is the use its life?” (ibid., § 432)

The meaning of a word can be very different in various settings, not because words would have predefined meanings but because words are used differently in different settings. That is, the use of words is situational. Hardwick (1971) interprets Wittgenstein’s concept of language to mean a system of signs in which a particular word is used. A situation (in which a word is given meaning) implies something else than a context. The context can, for example, be a cultural context (ibid.). If we only consider a word in terms of context, its dictionary meaning is given. However, a situation is not possible to put into a dictionary. Hardwick relates this distinction to the discrimination between language and speech, where speech is situational and language is an activity where we do things with already given elements of language. In a language game we use language. Consequently, a science language game, is here related to the school science context whereas differences and unique items are seen as situational aspects that can be dated to a specific time.

Words do not have a number of meanings; instead words are given meaning when they are used. This idea can be illustrated with the word ‘ecologic’ that can refer to a biodynamic cultivation of vegetables whereas in a scientific
context the word refers to a domain of biology. Similarly, Wickman (2004) refers to meaning as something that is seen as a consequence of use instead of a mental representation of a state of things in the physical world. In one context a particular word can be given one meaning and in another the same word can be used ironically, meaning the opposite thing. In addition to these two applications, the word may be used in other feasible ways. That is, words are given meaning in action in accordance with our purposes. Another illustration of how words are given meaning in action, instead of beforehand, stands out if we consider a person entering a shop and approaching the shop assistant. Not until the person entering has performed an action of purchase, can he/she be called a customer – until then he/she could as well have entered the shop for a chat with his/her neighbour the shop assistant. For the purpose of this research, the subject is defined by his/her actions. This consideration implies that certain actions are not anticipated from the participants, which means that classroom practice is studied without pre-defining the participants’ actions.

**Companion meaning**

As an aspect of meaning making I now address companion meaning and normativity. When we communicate about the nature within a scientific setting, we give our utterances scientific meaning. Furthermore, how we express, what words we choose and the topics that might be relevant are also part of our meaning making. Science students, for example, the students in this research, are about to learn scientific meanings (content meaning). At the same time, they learn what words are appropriate and how these words are used. As this research focuses on students’ talk in the realization of school science activities, the discrimination of these two aspects of meaning making implies possibilities for useful distinctions.

Östman and Roberts (1994) discriminate “extra” meanings apart from the scientific meanings. For example, they suggest that a view of the relationship human beings and nature can be communicated along with the science content. These meanings, which are embedded, for example, in a science text or an explanation of a scientific phenomenon, Östman and Roberts denote companion meanings. They describe companion meanings as follows:

“… communicated by explicit statements in the classroom or the textbook, but sometimes the communication is implicit, in that teachers and textbook writers quite naturally take it for granted that students will attach certain meanings to what is being said or read. Other implicit communication is accomplished, just effectively, by what is not said” (ibid., p. 2)

Furthermore, companion meanings communicated implicitly or explicitly, can be deliberately or unintentionally incorporated in statements about science. Lundgren (1979) gives an example that could be used to illustrate companion
meaning. He claims that when you learn (for example) science, you do not only learn science content but you also learn normative meanings related to it. You may learn what can be considered knowledge as well as what is considered valuable to know. These normative meanings are companion meanings. Those who participate in the actual language game make the companion meaning, as it is part of our socialization. I bring up the companion meaning because it has essential impact on what is expressed in the school science activities and how it is expressed. Östman and Roberts (1994) stress the importance of studying language usage to detect companion meanings in science classroom.

For the purpose of this research companion meanings are relevant, not only because they point out how to talk about the issues at stake but also because they are normative meanings that are based on values. Such values concern, for example, relevance or applicability. A curriculum (or an orientation in a science course) involves companion meanings about science, for example, about “the usefulness of scientific conceptions and explanations” (ibid., p. 4). Roberts (1998) explains that different currents in the companion meanings in a curriculum make up a curriculum emphasis. For instance, “everyday coping” is one curriculum emphasis that deals with students’ socialization to “grasp science as a way to make sense of objects and events of fairly obvious everyday importance” (ibid., p. 8). Another curriculum emphasis is called “solid foundation” and it argues the cumulative development of knowledge as important. It can, for example, be stressed that a student needs to learn something particular in order to understand what will be dealt with later. The two examples given here refer to two different values of scientific knowledge. In the first example, the value of knowledge is related to students’ lives in general. In the second example the value of knowledge is related to their participation in future courses. Similarly, a communicated companion meaning in this research relate to values.

Differences between settings
Thus far, language games with the associated meaning making, companion meaning included, have been addressed. In the following paragraphs I focus on how it could be possible to identify a language game despite, for example, every conversation being unique. That is, my starting-point is that classrooms look different and that pupils and teachers all have different interests and experiences. If we look at all these differences and combine them, we easily realize that the possibilities to combine them into unique and very different circumstances are almost infinite. Nevertheless, if we enter a science classroom it is likely that we identify some features of school science. It is likely we come across the triadic dialogue that Lemke (1990) mentions. Similarly, in an introduction of school science, science education can be presented as something esoteric, dangerous and different (cf. Delamont et al, 1988).
However, it cannot be expected that every introduction to science present these features. Resemblances between different classrooms or practices make it possible to talk about science education and a language game of school science, despite the many and important differences.

Not only are there crucial differences (and resemblances) between practices; there is also change to consider. Wenger (1998) claims that practices change. However, if the item studied is subject to change the identification of it might be difficult. Classes and lessons are different and we may ask how it is possible to identify a practice if the unit of analysis is not properly determined. Nevertheless, no matter whether talking about practices, language games or science classrooms in general, it is indeed possible to distinguish these. There are resemblances despite differences between various units. Roth (2005, p.259) strongly questions the idea of “stable and recurrent patterns of talking” as utterances are made in situation and undergo change of the moment. He suggests a continuous approach of studying language. Despite the change that Roth refers to, I argue that patterns can be found and that a science classroom conversation could be identified as a school science conversation. The resemblances (patterns) that occur among science classrooms are family resemblances (cf. Wittgenstein, 1953, § 67). The prevalent ways of acting and talking that can be seen in school science (cf. Östman, 2003) make up these resemblances and make it possible to distinguish a science language game. Consequently, a challenge for research is to identify features of school science that can be seen as family resemblances between science classrooms. When studying the realization of school science, as here, such features are displayed. My starting-point is similar to Roth (2005) when he argues against the idea that language is a medium of expression.

What is regarded relevant, important and appropriate in a particular setting is subject to change. Wertsch (1995) uses the concept mediated action and illustrates how new items can change the premises of action and transform them. Wertsch’s illustration includes individuals that perform actions as well as mediating tools. His point is that when new mediational means (tools) are introduced, the action can become very different. Wertsch explains the word mediation by referring to pole-vaulting. Originally pole-vaulting was performed with bamboo poles. When the fibreglass pole was introduced it implied new mediational means. However, the sport needs to be understood in terms of the mediational as well as individual means. Neither of these two makes up the activity by itself. When the fibreglass pole was introduced a question was raised: were those using fibreglass poles participating in the same game as the others? Evidently the participants who had fibreglass poles performed much better. The improvement was not only achieved because of the material of the pole but also due to new techniques and skills required for those
who used the new kind of poles. What Wertsch illustrates is how tools and action go hand in hand and how a transformation of a mediational means (for example, the tool) changes what we regard appropriate and genuine participation (in, for example, pole-vaulting). In the previous example the tool was radically changed but the activity was still pole-vaulting. That is, what makes it possible to distinguish that game are the different family resemblances between these two ways of pole-vaulting. In a similar way we can regard school science and the artefacts of the science classroom as mediational means of the school science activity. For example, the school science laboratory equipment mediates particular actions. The specific equipment is made for certain purposes that relate to, for example, how to carry out experiments and the safety issues involved with them.

**School science – a learning practice**

The previous paragraphs focused on how a science classroom is possible to identify despite the many differences between them. The next few paragraphs will explain how school science is regarded in this thesis. I have already stated my position that transitions can be made between the different ways of meaning making in school science. This gives rise to the question whether school science activities comprises more than one language game or if school science should be regarded as just one language game. Brown, Collins and Duguid (1989) present ideas that I relate to the first-mentioned position. They describe school as a hybrid culture, that is a culture in itself although school activities sometimes are borrowed from other cultures. Yet, cultures outside school are not appropriate models for activities in school (Carlgren, 1999). In pre-modern societies apprenticeship systems are used and these involve learning in authentic practices. Carlgren suggests that school could be considered an authentic culture with learning purposes. Then, school practice could be regarded in analogy with practices outside school.

Dewey (1938/1998) argues that education is an essentially social process and he supports his statement by saying that the development of experience comes about through interaction in a community group. From my point of view such a community needs to be related to the purposes of the group, in this case educational purposes. Consequently, the community group that Dewey refers to can be seen as the participants of the learning practice exemplified above. Dewey (ibid.) emphasizes the teacher’s affiliation to the group and claims that it is absurd to exclude the teacher from membership in the school science community. However, from my point of view, an inclusive standpoint (cf. Dewey, 1938/1998) does not imply that all individuals participate in the same way. Such illustrations are given by Rogoff (1995) who uses the concept of guided participation to refer to a “system of interpersonal engagements and arrangements that are involved in participation in activities /…/ which is
managed collaboratively by individuals …” (ibid., p. 146). Rogoff also suggests a perspective called apprenticeship that elucidates “the development of mature participation in the activity by the less experienced people” (ibid., p. 142). The latter of these two perspectives (apprenticeship) catches the teacher’s participation (as a master participant) more clearly. However, in neither case is the teacher excluded as a participant.

I previously made clear that subjects are defined by their actions in this research. This position fits with looking at the participants of the language game without predefining their actions. Furthermore, the position renders it possible to catch sight of a teacher’s learning as well as a students’ leadership. Despite these considerations, I will refer to “the teacher” and “the students” for reasons of convenience. It is appropriate to talk about these participants because the expectations of their different ways of participation are still essentially different.

4.2 The concept of experience

The introduction hinted at a teacher’s agenda for building teaching on students’ previous experiences and I will now develop the concept of experience. I begin my explanation of the concept of experience by referring to Dewey (1938) who describes experiences as a moving force that might set up desires or purposes. After that I give an example that is intended to explain the concept and to some extent illustrate already presented theoretical ideas. The value of an experience can only be judged on the basis of its consequences, Dewey claims. An experience produces consequences, for example, when we tell somebody about it or act upon it in some other way. In accordance with these ideas my intention is to study the consequences of students’ previous experiences as they become purposeful as mentioned by students. The concept of experience that is presented here fits with the concept of language games. For example, the meaning of an account of experience needs to be understood in relation to the setting where it is given and the consequences when it is shared. In the following quotation, Wittgenstein (1953) argues that representation of words is seen in how they are used. My interpretation is that Wittgenstein’s use of the word ‘sentences’ also comprises (utterances about) previous experiences.

“If it is asked: ‘How do sentences manage to represent?’ –the answer might be: ‘Don’t you know? You certainly see it, when you use them.’” (ibid., § 435)

Consequently what is possible to pay attention to regarding experiences is what becomes relevant and that is an account of experience. The account of an
Students’ participation in the realization of school science activities
Mattias Lundin

experience is a (part of a) previous experience that has come to use. The experience is then acted upon. Accounts of experiences appear in situations when a new experience is made. In order to emphasize this situational aspect of experiences I call them re-actualized experiences (cf. Östman, 2003). The word “actualize” is to be understood in accordance with The Cambridge International Dictionary of English (Procter, 1995), where “will happen or take place” (ibid., p. 14) is given as explanation to the verb. For example, a state of affairs can be actualized, that is, happen or take place. A re-actualized experience is accordingly an experience that has been brought up again, in a new situation.

The idea that experiences are re-actualized implies continuity with the past at the same time the experience is transformed in the present. That is, a re-actualized experience is not a previous experience that has been moved to the present, but a transformation process of a previous experience in which an account of the (transformed) experience is given. The transformation is an example of how continuity is made in our lives. This way of regarding experiences fit with what Leontiev (1977/1986) writes about our representations of the world. He argues that no perceptional knowledge becomes set in a fixed mould. Although if the perceptual knowledge is kept in a persons head, it is not as something fixed but as something that moves and that contains contradictions (ibid.). Furthermore, my way of regarding re-actualized experiences includes different previous experiences, originating in different contexts. With different contexts I do not aim at special occasions of any kind, but at experiences of reading, experiences of participating in a conversation or experiences when looking at pictures, just to mention a few possibilities. Furthermore, a re-actualized experience necessarily refers neither to any particularly important situation nor to any special previous experience. It is just a sign of something that has become relevant in the present situation.

Previously, I focused on meaning making. A re-actualization of experiences can also be described as meaning making of previous experiences. A previous experience has become relevant and re-actualized in a new situation. However, the experience is not re-actualized in a vacuum (cf. Dewey, 1938/1998). Re-actualization occurs in a new situation, which is considered in relation to the previous experience. Dewey describes how we grasp meaning by taking objects “out of their apparent brute isolation as events, and finding them to be parts of some larger whole …” (Dewey, 1910/1997, p 117). To take an object out of its isolation is seen as considering the object in its context. The sound of a bell can make different meanings: as in doorbell, fire-alarm bell or telephone bell. Different contexts may suggest differently grasped meaning. An experience can change our prerequisites for further experiences, that is, one experience may provide new conditions for our actions. Experiencing and acting are closely related. Experiencing is cumulative and Dewey (1938/1998, p. 34) explains our
experiencing with the following words: “Every genuine experience has an active side which changes in some degree the objective conditions under which experiences are had.”

According to Dewey (1934) “every experience is the result of interaction between a live creature and some aspect of the world in which he lives” (ibid., p. 43-44). That is, we do something at the same time as we undergo the consequences of our actions. For example, as we lift a stone we undergo its properties. What is undergone plays a part the next time we perform a similar activity, for example, we may choose not to risk putting ourselves through another unpleasant activity. Wickman (2004) explains undergoing as a transformation of experiences. This doing and undergoing makes a continuity of experiencing. Dewey (1938/1998, p. 27) explains the continuity when he says “every experience both takes up something from these which have gone before and modifies in some way the quality of those which come after”.

Thus far, I have dealt with experiences on a theoretical level. The following last lines of this section (4.2) are intended to give an example of a boy’s experience and use the example to elicit an everyday use of the word ‘experience’. After that I will end this section by relating the example to the concept of language games.

Sometimes we use the word ‘experience’ in everyday situations referring to a particularly powerful situation. The everyday way of using the word ‘experience’ comprises an idea of experiences as something that is of special significance to us. This use of the word also fits with the previous explanation, although the concept of experience that I use does not necessarily require a situation of special significance. Helldén (2001, p. 110) gives an illustration of a re-actualized experience that might be of special significance and that deals with a boy who participated in a longitudinal research study. In every interview from nine to 13 years old the boy said that it is possible to put eggshells on the compost. The boy described the decomposition as mixing and fragmentation without microbes involved. When the boy was 19 years old he gave some background to what he had said in the previous interviews:

“We had a neighbour who carried out composting in a special way. I liked to be there with him. The man even put eggshells and coffee grounds [sic] on the compost. I remember the first time I was there and he asked me to empty a bucket with coffee grounds and some eggshells on the compost heap.” (Helldén, 2001, p. 110)

I will now try to bring about my view on the research setting by referring to Helldén’s (2001) example. In practices focusing biological issues it could have been appropriate for the boy to include microbes when describing the
Students’ participation in the realization of school science activities
Mattias Lundin

decomposition. However, in the situation at the compost heap, talk about microbes may not have been necessary at all. I would like to refer to the situation as to the boy’s and his neighbour’s participation in an everyday language game. The situation at the compost heap can be seen in relation to purposes of taking care of the domestic refuse and chatting with the neighbour at the same time. Talking about microbes can be purposeful in school science class and less purposeful in something that could be called an everyday setting.

The concept of experience (re-actualization of experience) that just has been given has power to explain occurrence of continuity with the past as well as other settings. A re-actualized experience that brings continuity with another language game implies a possibility for transformation. That is, what is brought from the other language game might provide change. At the same time school science activities can be seen as a “shared repertoire of ways of doing things” (cf. Wenger, 1998, p. 49). Without tools to consider change and continuity, an analysis of language games as something changing is difficult.

4.3 Studying language games

So far, meaning making has been explained as a part of language games and the line of argument has been related to the re-actualization of experiences. Furthermore, I have related differences between settings, such as science classrooms. The issue that now is to be addressed concerns how language games can be approached despite, for example, differences between the settings in which they are to be studied.

Szybek (2002) uses the word ‘stage’ when referring to situated meaning constitution. The idea of a science stage of events is similar to the idea of a science language game. Events that take place on an everyday stage can be characterized by a certain way of relating objects to one another, Szybek explains. That is, science language can be discriminated from everyday language, such as everyday school language game. During science lessons, one purpose for talking can, for example, be to explain natural phenomena and relate these to concepts that are given in the textbooks. During breaks and in leisure hours other purposes might become more important. Then, talking to classmates to socialize and have fun are potential purposes for talking. These kinds of differences enable the discrimination of language games. In the school science setting, an everyday language game may be used when a student’s experience is re-actualized. However, an unambiguous discernment of language games can hardly be made. Anderberg, Alvegård, Svensson and Johansson (2005) address students’ explanations in their research, of which some were
assessed as scientific language because the meanings were not contradictory to the associated scientific theory. Anderberg et al point out the complexity of language and their report indicates that language games are not necessarily easily discriminated.

The language game makes it possible to make meaning of actions (moves or utterances). Apart from the language game meaning disappears. Wickman and Östman (2002) explain that some utterances in a conversation stand fast. What stands fast in a language game does not need any further explanation to be understood. According to Wittgenstein (1969, § 150) we have to start trusting in our interpretation of other people’s utterances at some point. Everything cannot be doubted if we intend to go on with our conversations. The utterances that make such a starting point stand fast and are immediately intelligible to us. Communicative items that stand fast are important, as communication is only possible if the meanings of words are intelligible to the participants. Furthermore, if nothing stood fast there would not be any kind of starting point in conversations:

“If you are not certain of any fact, you cannot be certain of the meaning of your words either. If you tried to doubt everything you would not get as far as doubting anything. The game of doubting itself presupposes certainty” (Wittgenstein, 1969, § 114-115).

Consequently, in any conversation utterances that stand fast are possible to identify and as a conversation goes on we encounter new items, such as words or things. Some of the items that we encounter do not stand fast and then, some kind of comment will be needed to fill the gap that was encountered with the non-standing fast item. When studying the conversation we can notice how relations are established between items that stand fast and encountered gaps. That is, when we add a comment in a conversation the comment fills a gap. Gaps are possible to notice by their consequences (that is, when they are filled). Wickman and Östman (2002) use the analytic approach that is based on an establishment of relations to items, such as utterances, that stand fast. They describe the approach as

“…on the one hand describing what is standing fast in discourse (the already shared meaning) and on the other hand by describing how participants establish new relations in terms of similarities and differences to what is standing fast in an encounter (new shared meaning)” (ibid., p. 5).

That is, we can see that a gap has been encountered when a relation needs to be established. Relations can either be ‘differences’ or ‘similarities’. A ‘difference’ can imply a contrast that discriminates the related items. A ‘similarity’ on the other hand constitutes an analogy between the related items. In a conversation an increasing number of relations are established which
makes up a conversational change. This gradual change is one way to operationalize language games. The establishment of relations can be compared to what Dewey (1910/1997) says about grasping meaning that was previously described as finding objects to be part of a context. A further description of the method (Wickman & Östman, 2002) will be given later.

4.4 Theoretical choices in consideration

In the previous sections I have described my research perspective and presented my theoretical considerations. In the first part of this section, I intend to reflect upon the choices already made and point out a few alternatives. In the second part I address some ideas in sociocultural theories and relate these to the perspective that I use in this thesis.

A great deal of science education research has focused students’ ideas on various phenomena, sometimes expressed as students’ conceptions, using constructivist or social constructivist theories. Swedish research with that focus and which attaches to the subject content of the participating groups of students of this thesis, are Wallin (2004), Helldén (2001), Jansson, Andersson and Emanuelsson (1994), just to mention a few. Wallin (2004) uses a constructivist perspective focusing on how individuals develop an understanding of evolutionary biology. A similar choice could have been made here, too, although the emphasis would have been essentially different. Constructivism would also have implied an essentially different view on experiences. With the chosen perspective, experiences become something visible that can be studied in the realization of school science. Using this perspective the learning process is in focus, whereas a constructivist perspective is suitable for focusing on learning outcomes.

According to my interest in understanding the realization of school science, I find it reasonable to use a perspective that includes unique items of an ongoing conversation because these can provide a contrast to the established subject content. My perspective focuses situational aspects as it involves the participants’ encounters with words and artefacts in the school science setting. The gaps that may occur in these encounters are unique features. However, the chosen perspective also frames features of the activity that build continuity. Utterances that stand fast provide continuity in this theoretical perspective.

1 Phenomenography has been used to study qualitatively different ways in which people experience a phenomenon (cf. Brown, Abell, Demir & Schmidt, 2006)
Students’ participation in the realization of school science activities
Mattias Lundin

With the chosen perspective students’ re-actualized experiences are seen as something dynamic and changing. Another consideration prior to the choice of theory is the possibility of studying change (transformation). An already mentioned constituent that supports the study of change is the establishment of relations between items that stands fast and unique items that the participants encounter.

There are some points of similarity with other perspectives that I would like to point out. In conformity with discourse analysis, the perspective that I have chosen brackets off to what extent humans’ utterances represent mental conditions (cf. Potter & Wetherell, 1987, p. 178). My starting-point for this project resembles what Potter and Wetherell claim as significant for discourse analysis: “Our focus is exclusively on discourse itself: how it is constructed, its functions, and the consequences which arise from different discursive organization”. Similarly, I focus on the participants conversations and not on their intentions or states of mind and so on. We often act according to habits (about our customs cf. Östman, 2003) and in such cases we might not even be able to specify any purposes or reasons for how we act because they are woven into our habits. Potential inconsistencies between our actions and purposes, I regard as possible research objects.

The theoretical perspective given here is mainly based on Wittgenstein’s later works. My reason for this choice is that these ideas place focus on consequences of, for example, utterances. In relation to the Russian psychologists (cf. below for reference) the choice of perspective does not involve any controversies. Rather, I regard the chosen perspective as a possibility for studying communication in the school science setting, where ‘acting with purpose’ and ‘consequences of actions’ are two crucial parts. The chosen perspective is not built on the words of Russian psychologists. Nevertheless, the ideas are similar. For example, Bakhtin (1986) uses the concept of speech genres, which he explains as the forms of utterances that are mandatory (in contrast to lexical compositions and grammatical structure). Speech genres are necessary for mutual understanding, he argues. These ideas are similar to the language games and the idea of companion meanings presented here. Companion meaning are normative meanings concerning, for example, what is worth talking about. Similarly, Bakhtin describes speech genres as a normative aspect of language: “Speech genres /…/ have a normative significance for the speaking individuum” (ibid., p. 80).

Another Russian theoretical framework that provides similarities to the chosen perspective is activity theory (cf. Davydov, Zinchenko & Talyzina, 1982). In activity theory the activity constitutes the research object. In this thesis the word activity refers to a sum of actions that the participants accomplish.
together. Such a shared accomplishment of actions is to be related to the shared repertoires of doing things that were focussed in section 4.1 where the concept of language games was related to communities of practice. However, an activity does not have to be a set of actions that are prevalent or related to any specific goal of the practice. This position makes my concept of activity deviate from ‘activity’ in an activity theory perspective. The latter concept has four major related components: need, motive, goal and conditions associated with achieving the goal (ibid.). The focus on acts, their correlated goals and the prevalent conditions constitute examples that are similar to the focus on actions, purposes and the sociocultural setting, that are described in this research. However, my focus is placed on a micro level which means that less emphasis is put on societal needs and motives for goals and their correlated actions. Activity theory turns focus on activity in a broader sense. I regard the activity theory as a possible continuation of the present study.

Culture (as in sociocultural) is a term that is sometimes used in this thesis and a comment on how I regard the relation between culture and meaning is important in order to provide unity. Geertz (1993) illustrates cultures as webs of significance. These can be interpreted in terms of meaning, providing a system of meanings. My emphasis when studying language games is that such a system helps us to establish meaning. From my point of view there is no pre-existing meaning of words, meaning is made as words are used. Säljö (1998) points out a similar idea when he says that learning does not occur in isolation but is dependent on society and culture. That is, what we say and do need to be considered in relation to its consequences. Utterances are dependent on society, culture and also our aims and purposes in the setting where we act. Säljö explains that the link between cognition and culture is discourse. The consideration that I have presented is that the language game constitutes such a link. Language games can in this respect be seen as a parallel concept to discourse.

A crucial emphasis made in this research is on the assumption that meaning of words is seen in the employment of them (Wittgenstein, 1969, § 61). A similar assumption is made by Säljö (1998). He argues that the traditional view of language, as a representational device where “words and concepts primarily represent the world” (ibid., p. 43) is not a valid position in sociocultural theory. What I point out as central in the perspective used here is (as stated above) that words become meaningful when they are used in a human and cultural activity. Säljö (1998) emphasizes meaning making in relation to context rather than in relation to the consequences of utterances (the application of the utterance). However my intention is not to draw a dividing line. On the contrary, I would like to point out that the applications of words and artefacts can often be seen in purposes embedded in a setting (for example, in the culture of the practice
where they are found). Similarly, Säljö (ibid.) illustrates that words for communicating fine distinctions can be found in social practices where such are functional. Accordingly, the idea to consider speech acts in relation to the social practice they function in, is part of this research project.

In this chapter I have focussed on distinctions that are necessary for studying the realization of school science and its different features. For example, I have brought about concepts that facilitate catching sight of school science as a particular place for meaning making. Furthermore, concepts that elicit unique items (for example, re-actualized experiences) and items that provide continuity have been presented. In the next chapter I will develop the purpose of the project and present the used research questions.
Students’ participation in the realization of school science activities
Mattias Lundin
5 RESEARCH QUESTIONS

I previously pointed out that the research perspective is chosen in order to enable the study of features of the realization of school science. My research aims at providing understanding about the participants’ actions, implying search for explanations that fit with the situational circumstances rather than with the participants’ inner motives. The idea is to catch sight of what can be argued are applicable approaches in school science from a participant’s point of view.

The purpose of this project is to provide understanding of how students’ experiences and questions on one hand, and an already established science content on the other, are part of the realization of school science. Teachers’ consideration of students’ experiences is considered one agenda of school science whereas the consideration of the subject content is seen as another. In the realization of school science activities these different agendas need to be orchestrated.

The realization of school science activities will be approached by means of four research questions that can be found in the articles that are presented.

1. What features in science education orchestrate students’ participation (based on their interests and questions) with a specific science content?

2. How is NOS knowledge communicated in lower secondary school classrooms as a by-product of instruction on precision and procedures?

3. What role do questions play for transitions from an everyday way to a scientific way of referring to natural phenomena and vice versa?

4. a) What role may re-actualized experiences have in a school science setting?
   b) What is the impact of different agendas on re-actualized experiences?

The work on these research questions can also be seen as an opportunity to further explore theoretical ideas that have certainly been used in science education research and that seem applicable for these purposes.
Students’ participation in the realization of school science activities
Mattias Lundin
6 THE EMPIRICAL STUDY

This chapter reports on the chosen approach to data collection. First, the data collection is described generally; second, the focus is turned to specific features of each part of data collection work. These collections of data are referred to as ‘Electricity class’, ‘Optics class’ and ‘Human biology classes’. The last part of the chapter consists of reflections on the chosen approach.

6.1 General approach to data collection

A major consideration for my data collection is based on the interest in school science activities in compulsory school. Ordinary schools, with ordinary students, working without my interference in planning are studied. The use of the word ordinary should not be interpreted as a claim of generality. Neither the class nor the teaching methods used are considered to be ordinary in any statistical sense. However, to prevent showing rare examples, obviously exclusive samples have been avoided. I have, as much as possible, tried to avoid making an impact on the classroom work.

Headmasters of schools were contacted some considerable time before my visits were to take place. In fact, several headmasters helped me to get in touch with teachers. I explained my interest in the realization of school science and so-called science talk, to the teachers. Most of them seemed interested, although in some cases, various events were planned and my participation was not suitable at that time. For that reason I chose not to involve these classes in my further preparations. My hope was to participate during science lessons, record on videotape and to make notes about the realization. In all cases, the choice of students was made for practical reasons and not for the purpose of showing any particular teaching approach. As a very first step I visited the classes that showed an interest in participation. During these meetings I told the students about myself, my role and about my project and they welcomed me to their classroom.

On all occasions when collecting data I brought equipment for making video and audio recordings (in one case only audio recordings). The camera focused on different groups of students every lesson in order to avoid exaggerated interference. During full class lessons the camera focused principally on students and not on the teacher. I considered that the presence of a camera over a long period of time would not be noticed continuously.
To use video for data collection has both advantages and disadvantages. First of all, it is possible to go back to the material repeatedly. Video recordings can be seen as ‘more’ empirical material than, for example, field notes, which is an advantage because the talk and actions that I focus on can be hard to do justice to with field notes only. Neither approach can be regarded genuinely better, but for my purposes it is an advantage to be able to have a renewed look at the video material. I consider that as a great opportunity, even though the video recording does not equal the original situation.

6.2 Researcher’s role and attitude

To be present in the classroom as a researcher can imply certain problems, especially if the researcher also has a teacher training. For example, students may expect you to act as a resource person for them. In the written information to the students and their parents it was emphasized that my role in the classroom was that of a researcher. However, being an adult in a classroom involves obligations. Even if I had not had a teacher training, the situations could have been similar. As an adult in a science classroom, students could expect help from me, and that indeed happened, although I stressed my role as a researcher. I agree with Sahlström (1999) that an important part of this type of research is to assure students that researchers are not teachers. Nevertheless, to participate strictly as a researcher can involve ethical dilemmas, at least if the researcher’s role is based on observing and taking notes. From my point of view, being an adult among children always involves a responsibility and that responsibility goes beyond any purposes of being a researcher. That is, as an adult you are obliged to actually take up the role of a “managing” adult if needed. I regard that as a part of the responsibility of adulthood. The latter position diverges from Sahlström’s (ibid.) claim that researchers must spend time with students “without taking up the roles of ‘managing’ adults” (ibid., p. 51). Fortunately, I did not come across any situations where my role as a researcher was jeopardized. Maybe, presenting myself as a researcher from the start in order to gain a distinct role (albeit multifaceted) assisted the prevention of such dubious situations.

My role was not only constructed by myself but in co-operation with the students. I dealt with upcoming minor situations by referring to the fact that I was not their teacher and to the fact that I was not sure about how they were supposed to carry out tasks. Nevertheless, the students encouraged me to take different roles, probably because of their different needs in various situations. For example, when the teacher was not available to answer questions, it could be convenient to ask me instead. In other situations they tried to involve me in
their talk about the future or asked me questions about my work, just to mention two examples. These cases offered opportunities for me to learn about the students, which I regard an advantage when being interested in their activities. In cases when the participants were divided into groups, I made a conscious effort to approach many different groups instead of spending much time with a single one. Accordingly, I tried not to interfere too much with a single group but to spend some time with all groups. To sum up, the best way to describe my role is as multifaceted. My role had features of a teacher, adult, friend and a researcher, although my primary task was to have a researcher’s viewpoint, grasping the participants’ activities.

Conducting research in a classroom implies interference with the ongoing activity. Whether the researcher is present or a video camera has been placed in a classroom, the setting has been changed. From my point of view, taking a distinct role may imply that you become less exciting because students then become aware of your presence and of what you are doing. Less excitement about my presence meant that they could work without bothering much about the camera or me. The installation of a video camera drew a lot of attention the early days. At that time students were eager to look at the camera and they asked me about its functions. However, they soon lost interest in the camera and afterwards they paid very little attention to it. An advantage with my approach is that I never managed the video recording behind the camera for any long periods of time. That is, I often just adjusted the focus and then left the camera alone. Maybe doing so contributed to the decrease of interest in it. The approach also implied that I was able to see how the students worked and what they said when I was not attending their particular group. Only occasionally some student remarked to the rest of the group that there was a camera around. On such occasions their conversations about issues that they might have regarded inappropriate, stopped. I take that a good sign, implying that they may have felt at ease most of the other time. It also indicates what students might regard as inappropriate topics during lessons.

6.3 Comments on ethics

The participating groups of students were chosen by convenience and rested upon the teacher’s and the students’ interest to participate. At the initial meetings when my project was presented, students were informed about my possible presence in their classroom and written information was handed out to the students. This written information was not only intended for the students but also for their parents and it contained a form for the parents to sign, in order to give consent to having me recording (mostly video recordings) in their...
Students’ participation in the realization of school science activities
Mattias Lundin

child’s classroom. The meetings with students and teachers, as well as the written information, complied with the research ethical principles of the Swedish research council regarding the importance of distribution of information (Vetenskapsrådet, 1990).

Written consent is not sufficient to cover an entire project (Brickhouse, 1992). Consequently, when carrying out research in the classrooms I also regarded students’ continuous consent to be essential. Although a student has agreed to be video filmed, he or she may change his mind. I emphasize the significance of being sensitive to students’ approval. I aimed for extensive material as I participated during whole projects. Therefore, I could sincerely tell students that there was no problem caused if anybody, for example, felt that they did not want to be recorded. Once a girl asked me to turn the camera to a different angle in order not to make her feel uneasy. Of course that was done immediately. From my point of view, being sensitive regarding the informants’ wishes and requests is as important as the formal, written consent. To give this additional information to the participants was one way of dealing with the demand of consent (cf. Vetenskapsrådet, 1990). The parents’ consent was relevant as participants were less than 15 years of age. I argue that the recordings made for my project were not ethically delicate. However such occasions cannot be foreseen and written consent also has other advantages. For example, it is a way to facilitate contact with parents.

In the written information, students and their parents were informed that personal names as well as the name of the school were to be concealed, in order to provide anonymity for them. However, complete confidentiality can never be promised in research that is based on field work (Brickhouse, 1992). For example, participants can jeopardize the confidentiality by telling others about their participation.

This far I have told about general features of the data collection and about participation during science lessons as a researcher. However, the data comes from three sources and I will now provide specific information about each source from which the data was collected.

6.4 Settings for data collections

Data was collected in three settings and the material that was gathered has been combined in some of the articles. Below are some details of each setting presented in the same order that the collection of data was carried out.
6.4.1 Electricity class

This data was collected over a period of seven lessons dealing with an introduction to electricity to 13-year-old students in lower secondary school. The 40 students were divided into two groups, taught by two teachers. In both of these the topic can be called ‘Introduction to electricity’. The groups worked with a few tasks every lesson. Prior to these tasks the teacher gave explanations and instructions. After practical work, concluding remarks were summed up. The video recordings that were made during most of the lessons (10 hours in total) had the teacher in focus. Since the students were not in focus, video observations of students who did not want to be recorded could easily be avoided. All conversations where the teacher was talking were transcribed. The data collected was used in the text “Experiences and their role in science education” (Article 4) and in that text this source of data is named ‘school B’.

6.4.2 Optics class

The participating students were 11 – 12 years old (school year 5 - 6) and they came from two different classes, which were mixed and formed into several small groups. I observed them during a project dealing with optics that they themselves referred to as ‘light’. The data consists mainly of documents and field notes taken at six out of nine occasions when they worked with their project. The approach used by their teachers was based on an introduction where students asked questions and explained what they thought were answers. After that the students were supposed to plan their group work by answering the following questions:

- Who does what?
- Where can facts be found?
- How will we present our findings?
- How will we document our work on the website?

The students worked accordingly. The analysis of the data from the electricity class, supplemented with observations and some audio recordings in the ‘optics class’, resulted in the article “Experiences and their role in science education” (Article 4). The ‘optics class’ is named ‘school A’ in Article 4.
6.4.3 Human biology classes

This third source of data collection was collected in two classrooms at the same school. In both of these classes the students dealt with the human body as a topic. The students were 11 years old in one of the classes and 15 years old in the other. The video recordings of this (double) data collection focussed the students and they cover 13 and 17 hours respectively.

The 11-year-old group of students worked on a human biology project. They spent much time working in groups, trying to find answers to questions which they had formulated during a previous lesson in full class. The teacher had the role of a supervisor who supported their work to prepare a presentation at the end of the lesson sequence. As an additional element during the project, the students chose among laboratory work tasks, which the teacher suggested. Then, the teacher’s role was that of a supervisor. In the end of the lesson sequence the students reported their project work and the class and their teacher commented on the information given by each group. The sequence of lessons was evaluated with a test. Students’ practical work is sometimes referred to as laboratory work in this thesis. I have made that choice of words despite that for example the 11-year-old students did not have any laboratory because the phrase points out that their practical work is separated from, for example, such practical work as cutting and gluing paper.

The group of 15-years-old students also spent a considerable amount of time on group work. Their work started with a task where they were supposed to explain the digestive tract. Their explanation was intended to start with a mouth of food and end with the use of the nutrients. This task was extensive and took place during the students’ first eight lessons. The lessons that followed these contained dissections and full class conversations about organ systems (in addition to the digestion, the cardiovascular system occupied most of their time). When the students worked on the first-mentioned task, their teacher functioned as a supervisor whereas her role embraced more lecture like elements during the later lessons. The sequence of lessons here was also evaluated with a test.

The human biology classes provide the major contribution to the empirical material. The data that is used in the articles “Building a common platform on students’ participation” (Article 1), “Meaning making of precision and procedures in school science” (Article 2) and “Questions as a tool for bridging scientific and everyday language games” (Article 3) was collected in these two classrooms.
6.5 Transcribing

Video recordings are valuable as they make it possible to reconsider what happened in the classroom. Transcripts are also required in order to carry out an analysis with accuracy. It is important that the transcriptions are thoroughly made and a careful transcription is a prerequisite for a trustworthy analysis. However, I cannot but provide my version of what is said in the classroom. Furthermore, a transcript only shows a few aspects of a situation. In my transcriptions the participants’ conversations are in focus.

In some of the transcripts, special markings were used to indicate features of a conversation that otherwise would have been overlooked. For example, transcripts can point out the length of pauses or when two utterances are joined without a pause. The used markings can be found among those recommended by Hutchby and Wooffitt (1998, p. vi):

<table>
<thead>
<tr>
<th>Marking</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>short break</td>
</tr>
<tr>
<td>(2 s.)</td>
<td>2 seconds break</td>
</tr>
<tr>
<td>=</td>
<td>following turn comes without break</td>
</tr>
<tr>
<td>:</td>
<td>prolonged sound</td>
</tr>
<tr>
<td>(   ) [single parenthesis]</td>
<td>said with silent voice/difficult to hear</td>
</tr>
<tr>
<td>(   ) [double parenthesis]</td>
<td>my comment</td>
</tr>
<tr>
<td>[underline]</td>
<td>with emphasis</td>
</tr>
</tbody>
</table>

My intention has been to incorporate the information required for the analysis in the transcript and omit what I considered irrelevant. This consideration was done in order to balance readability and still be faithful to the original spoken language. Conversation analysis (Hutchby & Wooffitt, 1998) provides further possibilities for noting, for example, intonation. However, in this thesis intonation is not a crucial part of the analysis. Consequently, markings that point out intonation have not been used. Nevertheless, additional comments to the transcript (marked with double parenthesis) can point out special occasions when a feature, for example, intonation, is crucial but does not yet stand out by the markings. This consideration was made to facilitate reading.

Spoken language does not consist of sentences with full stops. These were interpreted when transcribing, if they are included in the transcription at all. In the articles which form a large body of this thesis, different positions have been taken. In some cases, notations have been used to show sentences. That position is made to facilitate reading. It is reasonable that the reader can easily follow the transcript but a further interpretation is made if sentences are indicated. I regard this issue as a question of accuracy and readability. After all,
transcriptions are tools for communicating features of a classroom situation (cf. Linell, 1994). My position is similar to the comments of Mercer (2004) on transcriptions. According to him the transcription choices should be determined by the research questions. For example, they (that is, Mercer et al) do not usually record details of the length of pauses made by speakers, which he explain is common in transcriptions of conversation analysis. Above, I have made explicit how pauses are transcribed in the conversations where such notations are relevant. Consequently, my position is similar to Mercer (2004) who transcribed, for example, non-verbal utterances when judged as relevant. Another factor that further complicates the transcriptions is translations. The participants speak Swedish and the transcripts presented are in English. Translations are difficult because they need to be accurate and trustworthy. Words that are prevalent in Swedish schools may not have an English counterpart. Similarly, one topic might be prevalent in Sweden whereas in other parts of the world it may be impossible to discuss. My starting point when making the translation has been based on presenting the object of analysis and making necessary adjustments without jeopardizing the analysis. From my point of view, it is not possible to preserve all features when translating. A reasonable solution is a careful treatment of data with the research questions in mind.

6.6 To analyze language games

In previous chapters the concepts of interest, students’ participation and previous experiences were elaborated. The purpose is not to examine these terms further, but merely to show how they are used in the analysis. When referring to students’ participation, I aim at participation that makes students’ previous experiences, their interests, ideas and questions relevant in the classroom conversation. That is, a student asking a question is considered to participate. This standpoint does not mean that a student could not participate by quiet listening. The word participate should be seen as a generic term for students’ active and extrovert participation. Furthermore, students’ questions are interpreted as indicators of interest. However, questions do not need to be expressions of interests, yet they are occasions in which it is possible to communicate interest. That is, I do not analyze interest; only occasions that open up for students’ interests. Occasions when students ask questions provide possibilities for them to express their interests. Questions can also be a promoter for participation. When a teacher seems to anticipate an answer it is likely that the students provide one. Similarly, a teacher (or a fellow student) can appear to anticipate that a student participates by asking a question. Students’ previous experiences may be actualized when questions are asked,
for example, due to an inconsistency between something observed and an experience. An experience may also be actualized when an answer is to be formulated (for example, as a teacher asks what the students know about a phenomenon).

Anderberg et al (2005) define “everyday” explanations as those that cannot be classified as science language. Similarly, I have defined everyday language games to be based on different ways in which meaning making can be made in school generally, such as during breaks and so on. However, my idea is not to pre-define the everyday and the science language games but to analyze the participants’ talk to see how distinctions are made in the spoken language. That is, to be able to determine a transition between two language games, a distinction or some other discriminating comment is needed. I regard this as a way to analyze language games as consequences of spoken language. This position is in line with Anderberg et al who suggest that meaning needs to be focused as a part of a student’s activity.

The research interest in this thesis deals with the realization of an activity that may encourage students’ participation on the one hand and that may orient toward an established subject content on the other. To enable a study of conceivable tensions between students’ participation and a particular content, a tool that manages to elicit how these two items are interwoven is needed. The analytic approach that has been used builds on the ideas of Wickman and Östman (2002) that were presented previously. I will now focus more on how these concepts are used in the analysis.

Wickman and Östman (ibid.) analyze learning by looking at the establishment of relations in classroom conversation. Their method is based on the idea that some utterances stand fast in a conversation. These are immediately intelligible and there is no need for questioning them. That is, what stands fast is not open to interpretation because meaning is then “evident from the socially shared rules of a language game” (ibid., p. 604). The phrase “stand fast” originates from Wittgenstein (1969) who explains that utterances that stand fast are not questioned. In order to progress in a conversation it is not possible to question everything. However, from time to time it is necessary to question the meaning of utterances. Then, a gap has been noticed. Another example of an encountered gap is on occasions when an additional comment is needed. To fill the gap we need to relate an utterance to something that is standing fast, for example, by making an explanation or an ostensive definition. The created relation is either a similarity or a difference. For example, an ostensive definition of a colour can be done by pointing out a certain colour. The established relation is then described as a similarity between the word and the colour.
Everything we say to each other that is found meaningful, and consequently not questioned, stands fast. The establishment of relations is what develops a conversation and consequently these have particular significance in the analysis. Nevertheless, sometimes missing items—that is, gaps—become important. A reasonable question is then how a gap can be noticed. According to Wickman and Östman (2002) a gap is noticed when a question or hesitation is communicated. I recently emphasized the importance of bringing to the foreground details of transcripts that are crucial for the analysis. In order to notice gaps, signs of hesitation need to be transcribed. One such sign is the length of pauses. Yet the length of pauses is not indicated as a number of seconds in all my excerpts. This position was taken because a pause is not the only indicator of hesitation and a pause can be made for various other reasons. Somebody shaking his head or shrugging can also be signs of hesitation, perhaps implicating a gap. There are many possible things to transcribe but the more items that are added, the more difficult the transcription will become to read. Consequently, my intention has been to make clear when gestures or pauses become relevant for the analysis.

Below I present a short excerpt from the material (human biology class, 11-year-old students) to illustrate the concepts ‘stand fast’, ‘gap’ and ‘relation’. Just before the excerpt begins one of the students (Jenny) had shown different bones on a picture of the skeleton, to the rest of the class.

John: This transparent or this kind of=

Jenny: =This or that? (points at the picture))

John: E:h that close to the ribs
Jenny: There?
John: Yes (.)

“Transparent” stands fast in the conversation, it is immediately meaningful to them.
Jenny pointed out a gap between John’s “This” and the picture. That is, John’s use of “this” does not stand fast.
“close to the ribs” stands fast in the conversation.
A relation is established between “This” (in John’s first turn) and the picture.

In the conversation a relation is established that can be a beginning of a gradual discursive change.
6.7 Reflections on the chosen approach

Potter and Wetherell (1987) use ‘discourse analysis’ referring to a specific theoretical perspective instead of general research that is concerned with language in a social context. The theory they use does not discriminate utterances that ‘do’ things (as an opposite to describe, for example, requests) and from those that ‘state’ things (that is, describe). That is, according to their theory, all utterances have meaning and force. My theoretical perspective emphasizes that a difference between ‘do’ and ‘state’ can only be seen in the consequences of the utterance. For example, a descriptive utterance, such as “This room is really cold” (cf. the same example in a previous chapter) can be used to ask a person to close an open window. Similarly, Potter and Wetherell (ibid., p. 18) claim that: “People use language, like a tool, to get things done…” My emphasis is that we cannot go beyond the prevalent language game, when we use language. Of course we can choose, for example, genre as we speak, but our choice need to be according to the rules of the language game to make meaning.

Alvesson and Sköldberg (1994) criticize discourse analysis for focusing narrowly on language use. They claim that important issues might be left out if research is limited in this way. I argue that there are reasons for their critique, but as we only refer to one research perspective it is reasonable to say that the analysis used here brings about certain advantages (for example, an interpretation that strives to be close to the empirical material) whereas other analyses bring about their own advantages. In the analysis presented here, attempts have been made to try to widen the analysis by presenting the purposes that fit with the circumstances. This intention does not imply that the participants’ purposes are reported but that purposes that fit with the situation (activity) and the consequences of an action. That is, one purpose with saying “This room is really cold” is to have the window closed. However, the purpose of the person that uttered the words does not need to involve the interpreted intention. At least, such statement would be beyond the scope of this analysis. Consequently, my treatment of data is not strictly discursive in the sense Alvesson and Sköldberg (ibid.) describe.
Students’ participation in the realization of school science activities
Mattias Lundin
7 PRESENTING THE ARTICLES

Sections 7.1 - 7.4 refer to an extensive summary of each article. Conclusions are given in section 7.5.

7.1 Building a common platform on students’ participation.

This article sets out to examine how school science activities can encourage students’ interests and experiences while supporting a specific science content. Teachers might involve students’ interests and questions when planning a science project. However, students’ interests do not necessarily match the content in, for example, the course plan. Billig et al (1988) describe a practical dilemma of trying to compel students to “‘discover’ what they are meant to” (ibid., p. 54). We cannot expect students to discover crucial scientific phenomena when engaging in inquiry, they claim. Similarly, Driver (1983) describes a tension between the acquisition of knowledge and the use of students’ inquiries. However, there might be ways around this dilemma. Mercer (1995) points out how teachers guide the learning activity by eliciting relevant knowledge from students’ utterances. Teachers’ may also give feedback in order to generalize meanings and describe classroom experiences to create a shared experience of important issues (ibid.).

School science implies studying what people have said about nature, but science also involves change (Sutton, 1996). New scientific ideas are often initially brought about as claims, he explains. Ideas gradually become formulated as accepted facts. Sutton argues this tentativeness accompanies new ideas. In school the tentativeness can imply that everyday ideas are transformed to scientific ideas. This transformation involves tentativeness in the choice of appropriate words.

Experiments constitute another prevalent ingredient in school science. Millar (1989) claims that many school science experiments illustrate a distinguishing pattern, showing “what is involved in doing science” (ibid., p. 55). For example, experiments are performed not only to show phenomena but also to elucidate features of a science activity. This study focuses on how such features become part of the classroom activity during the realization of a human body project. The school science activity is studied by addressing the following research question:

- What features in science education orchestrate students’ participation (based on their interests and questions) with a specific science content?
**Empirical study**

To answer the research question video observations were made during a human biology project, in a school class of 12-year-old students. The analysis focused on features that encouraged students’ participation as well as features that can be referred to as a science content. Students’ participation was addressed by focusing on students’ re-actualized (previous) experiences. The first part of the analysis discriminated parts of students’ work that were either based on re-actualized experiences or on making new experiences from the educational resources at hand. Each of the two categories that were construed consisted of qualitatively different elements. For example, the first of the two categories was divided into two parts, consisting of individual work with previous experiences as well as common work sharing the experiences. Consequently, the “individual inventory of experiences” and “building a common platform of experiences” were constructed. It needs to be stressed that although the second category was subsequent to the individual inventory in many occasions, these are not sequential. Instead they occur in different circumstances, which will be shown in the results.

**Individual inventory of experiences**

The first activity supports the students’ participation as their experiences were asked for. For example, during a lesson the teacher invited the students to look at a plastic torso and invited students to “Think about what you remember and what can possibly be found inside this body ((aiming at a torso)).” Consequently, the students were supposed to consider individual previous experiences. Another example of individual inventory of experiences was found during students’ practical work. The teacher explained the word ‘hypothesis’ to the students by referring to what could be concluded from a laboratory practical in which students were supposed to bubble exhaled air into water, which had been coloured with an indicator for acidity.

When explanations were made, the word ‘hypothesis’ was connected to the formulations “what do you think happens” and “a guess” and consequently referring to predictions that could be based on re-actualized experiences. A prediction (‘hypothesis’) could be formulated as follows: “I do not think that I will be able to…” What discriminates this activity from the next is that it is based on individual work whereas the next is based on the group’s sharing of experiences.

**Building a common platform of experiences**

This second activity supports an establishment of relations between re-actualized experiences and the subject content. By sharing previously re-actualized ideas, the students built a common platform of re-actualized experiences for further talk. For example, when an experience was re-
actualized the teacher sometimes elaborated the student’s utterance in such a way that a common platform of science content was built upon the shared experiences. Sometimes the teacher guided the conversation to include further experiences that possibly could be relevant for the intended topic.

This activity also involved a formulation of questions that gave the students an opportunity to include their own interests. These questions constituted starting-points for the group work and could be formulated as follows: “What is the skeleton built of?”

**Sharing new experiences**
The third activity involves students’ experiences in the classroom concerning the subject content that was based on making and sharing new experiences. This activity comprises students’ work to answer the previously formulated questions. For example, students could be busy trying to make meaning of scientific words while referring to the textbook and their bodies.

There are occasions when the group of students seemed to have trouble in making the textbook information match their different previous experiences. There seemed, for example, to be confusion about the names of different parts of the arm. Those parts were crucial points of reference when proceeding with their task.

There are two activities that imply experiencing for the participants, apart from the activity mentioned above. ‘Building a common platform of experiences’ also implied experiencing. A major difference between these two activities is that the previous activity is based on students’ re-actualized experiences whereas this activity is based on textbooks and other information sources.

**Concluding a common platform**
This activity supports the establishment of science content more than students’ interests and questions. Control and verification of the newly shared experiences was made by concluding a common platform. The teacher had a distinct role as a master participant.

This activity provides support for solving ambiguities such as those mentioned in the previous activity, when defining the part of the arm. The teacher then provided information directly to students by pointing out the parts of the arm. Thus, the ambiguity was solved and the students could go on with their task.

The conclusion of a common platform also comprises clarifying uncertainties and emphasizing issues or items from a line of arguments or adding items to a line of arguments. However, in contrast to what was just illustrated, not only
Students’ participation in the realization of school science activities
Mattias Lundin

the teacher clarified uncertainties. Occasions when a student asked another student for clarification also occurred. The findings illustrate, for example, how the name of a significant tissue (cartilage) became relevant and was asked for. When the name of the tissue had been given, the teacher added explanations about what cartilage is. That is, the question provided an opportunity for the teacher to verify.

The four activities constitute a possibility to construct a foundation for participation in human biology topics. For example, the second activity seems to level out students’ different opportunities to participate in the subsequent task. The fourth activity implies a checkpoint of previously shared experiences. Nevertheless, I suggest further research to illuminate the possibility of integrating the two first activities.

To sum up, this article points out four inductively found activities that encourage students’ participation while they support a particular subject content. The activities provide means for involving students’ previous experiences as well as occasions where their own questions can become part. The activities also provide means to make sure that the outcomes are satisfactory. Furthermore, they provide a foundation (common platform) for participation in similar conversations by levelling out students various possibilities for participation as well as comprising checkpoints to control that meaning making is made according to the rules of the language game.

The article ‘Building a common platform on students’ participation’ is accepted for publication in ‘Journal of Science Education and Technology’.

7.2 Meaning making of precision and procedures in school science

This article sets out to examine how the ‘nature of science’ (NOS) is communicated as a by-product of instruction and it shows that precision and procedures are two central and non-negotiable parts of the school science activity. In the last part of the results I suggest a discrimination of ‘nature of school science’ (NOSS) from the NOS, in order to point out important features of school science practice and its rationales.

Research has described school science not only as involving natural phenomena as a subject content but also as the NOS. There are four assertions of the NOS that Khishfe and Abd-El-Khalick (2002) claim to be non-controversial: scientific knowledge is 1) subject to change, 2) based on empirical observations and 3) partly the product of human imagination and creativity. 4) Science
knowledge is also made with distinction between observation and inference. Furthermore they argue, “engaging in inquiry and learning about science process skills are not equivalent to learning about NOS” (ibid., p. 573). Yet, my position is that learning science content is accompanied by learning a practical epistemology (including, for example, the NOS). Osborne et al (2003, p. 715) emphasize that teaching the NOS should emerge from the process of scientific inquiry. Their position is consequently in line with Khishfe and Abd-El-Khalick.

My idea of learning the NOS agrees with Lidar, Lundqvist and Östman (2006, p. 162) who say that learning science content is always “accompanied by learning of a practical epistemology”. That is, for example, to learn “what counts as good questions, ways of acquiring knowledge” (ibid., p. 163). Munby et al (2000) describe features of school science that I argue can be learnt as a part of the practical epistemology. For example, science can be associated with structure, facts, techniques and precision. Delamont et al (1988), identify school science as an activity where precision and safety are central features. Precision is not only treated as self-evident but also self-justifying in school science (ibid.).

The purpose of this paper is to shed light on how the NOS knowledge is communicated in lower secondary classrooms as a by-product of instruction on precision and procedures.

**Emphasis on precision**

Precision was emphasized in the teacher’s instructions to students. For example, the teacher explained how a lancet was to be used to let a few drops of blood out and mix with reagents for blood groups A and B. The two reagents (anti-A and anti-B) were shown to the class. Then, the teacher explained that the reagents should be applied at least half a centimetre above the drops of blood and that the tip must absolutely not touch any blood. The precisely specified distance for pipetting was never explained or motivated, if anything, used as an emphasis to the claim that the precision was “really important”.

**Emphasis on procedure**

Emphasis on precision was often combined with an emphasis on procedure. For example, the teacher explained: “You take away this, the protective paper, just before you are about to use it ((the blood lancet)).” The in-detail description of procedures (cf. “just before”) was given as a boy suggested another approach by asking what would happen if the reagent got in touch with the skin. His suggestion implied trying out something exciting. The teacher answered that probably nothing special would happen. However, another boy made the question a little bit more alluring as he asked what would happen if the reagent
Students' participation in the realization of school science activities
Mattias Lundin

touched on a vein. The teacher turned that suggestion down. Shortly after that, the particular part of the procedure was repeated. That is, even though the boys’ questions/suggestions did fit with the subject, they were suppressed and procedural concerns prioritized. It was interpreted that the boys’ suggestions implied a threat against the procedures. The companion meaning was consequently that procedures were superior to issues regarding, for example, the consequences of the actions suggested by the students.

Just before the practical work was to start the procedure was repeated. The teacher asked if somebody could “repeat what I recently said about what you should consider when you check you blood group?” Then, a boy repeated the procedure by explaining the opposite to what they were expected to do. His suggestion is a way to say that the procedure indeed had become evident enough. The interpretation is supported by the subsequent turns where the boy (John) again was picked to repeat the procedure correctly. By urging him to repeat the procedure, the teacher stressed the importance that every student had to follow the appropriate procedure. This created companion meaning; there was no room for negotiating the procedures.

*Non-negotiable precision and procedures*

The previous paragraphs dealt with the emphasis on precision and procedures. I will now place focus on the non-negotiable characteristics of these two features of the school science activity.

The relevance of precision was communicated by saying that the stethoscope should be applied *exactly* in the bend of the arm and that only *one* finger should be used to hold the stethoscope. When practicing using the sphygmomanometer, the pressure was to be set to maximum 150. These non-negotiable matters were emphasized when the teacher told the students that they were not allowed to do the experiment unless they followed the instructions.

The procedure was, too, communicated as non-negotiable. The relevance of a chosen procedure was questioned by a boy (Mark), claiming that hospitals examine blood groups in a different way. Thus, he questioned the authenticity. However, the procedure was emphasized at the same time as the procedure showed not to correspond to professional blood testing procedures. The boy pointed out differences, which the teacher never explained. There was no room for negotiating the authenticity of the task. The issues of authenticity did not seem to be part of the agenda.

My interpretation is that precision and procedures constitute normative features of school science that do not need justification. Sometimes the procedures of
Students’ participation in the realization of school science activities
Mattias Lundin

School science might appear purposeless because they do not resemble professional approaches. Nevertheless, in school science many things have to be accounted for and some of them are not related to science. I suggest such features are referred to as the nature of school science (NOSS). Precision and procedures are two examples of distinguishing features of school science. The rationales for these two features can both be related to the NOS and the NOSS. For example, precision can be warranted from a student safety perspective. However, precision can also be argued for in order not to jeopardize accurate results in the laboratory. That is, precision from a NOS perspective is rational mainly for reasons of accuracy, whereas from a NOSS perspective precision is rational mainly for reasons of safety.

To sum up, this article points out three themes. The first two themes are described as emphasis on precision and procedures. Students’ questions and suggestions were answered in a way that favoured these components. The third theme deals with their importance: The findings point out precision and procedures to be two non-negotiable features of school science. It is suggested that if the rationales for the importance of precision and procedures were communicated, students’ participation could be facilitated. Furthermore, the concept “nature of school science” (NOSS) can be used to point out the particular features of school science practices and their rationales.

The article ‘Meaning making of precision and procedures in school science’ is accepted for publication in ‘Canadian journal of science, technology and mathematics education’. 2007, No 8(1).

7.3 Questions as a tool for bridging science and everyday language games

Research has focused on how students move between different ways of referring to the world. For example, students in non-Western cultures may construct parallel concepts for natural phenomena. Aikenhead and Jegede (1999) point out that these students need to effectively shift between the different parallel concepts. Such a border crossing between, for example, everyday activities and school science is a key to successful learning, they argue. This text does not focus on border crossings but on transitions between different ways of meaning making. The teacher plays an important part for facilitating transitions as well as border crossings. Mercer (1995) shows how a teacher can lean on students’ contributions (of, for example, everyday experiences) when proceeding with a topic. He points at the teacher’s possibilities to elicit, elaborate, confirm and reject students’ utterances. The
starting-point in this text is that school science comprises science ways to communicate as well as everyday ways to communicate and the transitions between them.

The purpose of this text was to show how science education is realized by using students’ experiences. In particular, research focus was placed on the role that questions have in a science classroom conversation. The research question was formulated:

- What role do questions play for transitions from an everyday way to a science way of referring to natural phenomena and vice versa?

Three examples were shown to illustrate the role of questions for transitions in school science:

**A teacher’s question evoking everyday experiences**
A teacher’s question can be described to easily evoke a student’s everyday experiences in a school science topic. The teacher asked the students about experiences made in everyday settings (apart from school). For example, the teacher asked for students’ possible previous experiences of vaccinations. The questions were responded to and the answers accepted. Consequently, it was in accord with the rules of the language game. Students’ experiences of vaccinations do not originate in the school science setting and when an account of experience is given in the classroom, it is possible that it is communicated within an everyday language game. The teacher sometimes picked up words from students’ answers and made the conversation cross to a science language game. That is, a teacher’s question can evoke a student’s experience from other language games. Furthermore, data show occasions when a question was answered and accepted, although the question developed the conversation in a direction that was changed by the teacher. Such conversations implied occasions for the teacher to point out what was relevant and irrelevant for the science language game. The next section focuses on occasions where students’ questions initiated talk about everyday experiences.

**A student’s question evoking everyday experiences**
A student’s question that is formulated in a science language game also has the potential to evoke students’ everyday experiences. For example, on one occasion the teacher explained how the blood is transported back to the heart through veins and how valves support the transportation. Then, the teacher suggested that some students probably had seen a person with dysfunctional valves, aiming at varicose veins. The teacher’s utterance was interpreted as a part of a science language game. The teacher’s tentative suggestion was followed by a student’s question regarding what this medical condition looks
Students’ participation in the realization of school science activities
Mattias Lundin

like. An attempt to answer was done by another student and it was based on an everyday language game. The teacher accepted the choice of words but changed to a science language game by adding the appropriate designation: varicose veins. The initial question implied asking for a relation to the phenomena that could be noticed in everyday settings and that corresponds to “defect valves”. That is, the conversation crossed from a science language game to the corresponding relevant everyday experiences. The next section goes further into students’ questions.

A student’s everyday questions evoking a scientific answer
A transition to a science language game is not easily made. I claim that everyday questions do not easily succeed in evoking science answers. In the following paragraph I relate the talk of three boys about the digestive tract, the kidneys and the formation of urine in a situation where they were about to write down facts about the digestive system and related topics. The boys’ conversation starts with Kevin’s question about where the excrement is separated.

Kevin’s concern dealt with two things: the separation of excrement (“what e:h rectum separates”) as well as the ‘kidneys’. An everyday language game makes it appropriate to talk about how we eat and drink and the subsequent visit to the toilet. As food and drink are mixed in our mouth it is reasonable to expect a place for separation prior to urine and excrement leaving the body. If we interpret Kevin’s question from a science perspective, the idea of one place for separation of excrements that includes the kidneys, is indeed difficult to manage because excrement and urine are not separated in one step, and there is no such thing as a ‘place for separation’ of urine from the contents of the intestines. Accordingly, the answer that was given by Kevin’s friend was based on a science language game and the explanation dealt with how liquid is absorbed from the contents of the intestines. Any answer to the first question can hardly be directly formulated in a science language game. In order to fill the gap between a ‘place for separation’ and ‘kidney’, a science language game question corresponding to Kevin’s question is needed.

Instead, the answer given explained how water is separated from the contents of the intestines. It dealt appropriately with the absorption of water into the blood, although it did not fill the gap between ‘place for separation’ and ‘kidneys’. Furthermore, it did not involve any place for separation where liquid (that is, urine) is absorbed from the solid matter. The conversation was still founded on two language games and thus the gap between ‘place for separation’ and ‘kidneys’ lingered.
As no relation was established, it is interpreted that no transition from the everyday language game to a science language game was made. Instead the language games remained parallel. That is, the previous example shows how a question (Kevin’s original question) can be asked in an everyday language game and still get a response in a science language game without providing any answer to the question. Consequently, the excerpt shows the difficulty in making an everyday formulated question fit into a science language game. One explanation to the difficulty is that such a transition implies entering an unknown domain. That is, an ongoing familiar everyday language game conversation is to be related to a new way of meaning making. Nevertheless, the situation provides an opportunity for a teacher to show to students how to make transitions between language games.

Furthermore, the questions provided opportunities for the teacher to notice and adjust students’ everyday explanations as well as everyday ways to talk. These opportunities can be seen as consequences of both students’ and the teacher’s questions. It was also interpreted that the questions implied opportunities to implicitly elicit the rules of the language game. For example, the teacher’s questions resulted in re-actualized experiences that could be approved (or rejected) as irrelevant in the language game.

The results imply that questions play a part in order to establish relations to everyday language games. The need for guidance not only stresses the teacher’s importance in general but also the teacher’s importance in creating a communicative practice where students’ utterances are considered. The teacher is significant not only for indicating what is part of, and what is beyond the language game but also supporting all students’ science talk even when questions seem unfruitful, irrelevant or misleading. That is, the teacher’s guidance provided support to keep focus in the conversation.

To sum up, this article points out how relations that bridge science and everyday language games are established in school science. The results indicate difficulties in making transitions from an everyday language game to a science language game. Without teacher guidance, students’ questions are potential promoters for making the topic drift and developing into something totally different from the topic as planned by the teacher. However, questions promote transitions to an everyday language game. These can be used by teachers, for example, to adjust an everyday explanation and guide students in making science knowledge useful in everyday settings.

The article ‘Questions as a tool for bridging scientific and everyday language games’ is accepted for publication in ‘Cultural Studies of Science Education’. 2007, No 2(1).
7.4 Experiences and their role in science education

The research interest in this article is on how we talk and act in school science. The results are presented by means of five features regarding the role of experiences in school science activities.

The starting point of this text is that differences of meaning making between school science and students’ lives in general terms can involve difficulties for students (cf. Bergqvist, 1990; Schoultz, 2000; Szybek, 2002). The research interest deals with how students’ previous experiences, originating, for example, in everyday contexts, might function and have meaning in a science classroom, despite difficulties. Tensions that might occur between individual experiences and the shared activity are in focus. Multiple purposes of the activity can explain tensions between different ways of acting. Such different conceivable courses of actions are here referred to as different agendas.

- What role may re-actualized experiences have in a school science setting?
- What is the impact of different agendas on re-actualized experiences?

Answers to the two research questions are presented continuously and in an integrated way.

Re-actualized experiences as a starting point

Calls for experiences can be found in science textbooks. The idea seems to be to use students’ experiences as a foundation for studying a topic: “Have you ever had to step into a car that has been too long in the sun on a summer day? If so, you know that it is even warmer inside the car than outside.” (Rydstedt, 1990, p. 48) The example seems to be designed to evoke students’ experiences of hot cars. An agenda of considering students’ experiences is one explanation of the approach in the textbook. One reason for founding the topic on students’ experiences is to facilitate a discussion about the subject matter.

When the teachers (school A) planned the lessons, students’ previous experiences were emphasized, for example, they claimed, “It comes naturally for them (the students) to deal with thoughts & [sic] ideas that they have in their surroundings.” In the teachers’ assignments to students’ it was also possible to see that experiences were included. The students were encouraged to discuss a number of questions and in co-operation make a mind-map. When following the teachers’ instructions the students used neither textbooks nor
other media to answer the questions. As they worked, experiences were re-actualized and shared resulting in a common foundation for further talk.

**Re-actualization of experiences made to a school task**

When the students had formulated questions, they were asked to write what they thought were the answers. This work was done prior to their use of textbooks. To write one’s ideas regarding a certain topic can be described as a way of re-actualizing experiences. “Why can’t we see at night” was one of the students’ questions. One answer was: “It is too dark”. As a third step, the students were supposed to answer the questions by means of various information sources (Internet, textbooks or with help from the teacher) and at that point the inductive feature of the task became clear. To the above question the student’s final answer was: “Human eyes are not made for night”. The task can be seen as a way of promoting the re-actualization of experiences. To write ‘what you think’ about an issue can be a very difficult task, especially if a student feels that he or she lacks relevant experiences. Under such circumstances it can be hard to grasp meaning of the task.

**Experiences as means for making students participate**

Teachers sometimes pursue the dialogue, trying to make students participate in a new topic. For example, once the teacher (school B) went on asking for more examples of occasions when electricity is used. More and more examples were asked for until the use of electricity was related to “bulb”. At that point, the teacher turned around the dialogue and a new line of questions began. The questions went on until the inventor of the bulb was mentioned. The language game here seems to provide a means for the teacher to guide the topic towards a specific point, the inventor of the bulb. Accordingly the re-actualized experiences seemed to play an important role in guiding the topic to the point where the inventor of the bulb was mentioned. Later on, the teacher and the students watched a video film about Edison and his invention. The example can be said to show how teachers can deal with two agendas at the same time. One of the agendas can be described as a consideration of students’ experiences and interests and the other as implementing a historical perspective in science education. The re-actualized experiences are means for reaching points that might be important from a teacher’s perspective. Disregarding the guidance of the topic to the point where history became in focus, the approach still comprises questions for experiences. The teacher’s approach to experiences can therefore be regarded as means to make students participate by relating everyday observations.

**Re-actualized experiences to show what is relevant in different situations**

Re-actualized experiences can be used by the teacher to show what is relevant in a specific situation. For example, a student can answer the teacher’s question
Students’ participation in the realization of school science activities
Mattias Lundin

by giving an account of an experience. If the teacher is not fully satisfied with the answer, he or she may turn to another student. On one occasion (school B) a student gave a reply similar to that of a student who had just answered. At that point, the teacher broadened the meaning of the words. As a result of such generalization no further similar answers became relevant in the changed context. This is a way of guiding the topic in an appropriate direction, turning focus to relevant applications.

Students’ attempts to fit their experiences into conversation
Situations where students asked for the teacher’s confirmation of the relevance of a previous experience are prominent. On one occasion the class (school B) was going to construct a battery and for that purpose a liquid was required.

As the teacher opened a bottle filled with a sal-ammoniac solution, a student commented, “It tastes good”. The utterance is here seen as a re-actualized experience of sal-ammoniac. The response given by the teacher, involved instructions regarding how to handle the substance. The teacher, for example, said that they should avoid getting it on their fingers and that they should wash their hands after practical work. An inconsistency can be seen as the student asked if the fluid is dangerous. The teacher replied that the students should be careful with those kinds of things. However, the inconsistency is intelligible because a substance can hardly taste good and be dangerous at the same time. The inconsistency lingered and a new question concerned the suggested caution in handling the fluid, in connection to its good taste. The teacher described the fluid as dangerous in very few words: “not particularly corrosive but try to avoid …” and “you should always be careful …” The teacher finally replied that you should not drink it. The inconsistency still lingered.

The previous conversation illustrates a dual set of relevant agendas, here referred to as a safety agenda and an agenda of building classroom talk on students’ experiences. The safety agenda is superior here. What also could be highlighted in the excerpt is the consequence of the student’s claim that it tastes good. The student’s re-actualized experience made the safety agenda relevant.

To sum up, the findings of this article show that both teachers and students paid attention to students’ re-actualized experiences, although the experiences were little elaborated. For example, experiences were a means of making students participate. However to make students participate is just one of teachers’ agendas. Safety is another agenda that seem superior compared to the agenda of building classroom talk on students’ previous experiences. Teachers’ work involves an orchestration of multiple agendas, here illustrated by safety and students’ previous experiences.

7.5 Discriminating the nature of school science -conclusions

The findings have pointed out the role that questions and experiences have for students’ participation in school science activities. Both teachers’ and students’ questions played an important part relating to everyday ways of meaning making from lines of arguments based on science language games. However, questions also played a part for relating science ways of meaning making to lines of arguments based on everyday language games. That is, questions can promote transitions from everyday language games to science language games and vice versa. Transitions from an everyday language game to a science language game seem to be difficult for students. One reason for the difficulty is that when translating from an everyday language game, students enter a domain that is unknown to them. However, a transition from a science language game implies relating an ongoing conversation to a familiar everyday way of meaning making.

The results indicate that checkpoints for concluding a common platform are a way to make sure that students’ questions and experiences match the intended science content. The teacher’s guidance played a part in keeping the conversation to the intended topic. The talk about re-actualized experiences provided occasions to level out students’ different possibilities to participate in the science topic. For example, re-actualized experiences were used to create a common platform for students’ subsequent work. The re-actualization of experiences was also a means of promoting students’ activity. However, despite the fact that both the teacher and the students asked for, or gave accounts of experiences, these accounts were not used as working material for elaboration.

The findings have also pointed out occasions in the classroom activity that opened up for students’ interests. Such occasions were found in situations where students asked questions or gave accounts of previous experiences. The results illustrate how students’ initiatives (questions and suggested topics or line of actions) can compete with other agendas of school science. Teachers’ work involves orchestration of different agendas. Their attention is, for example, directed towards safety issues or to sustain appropriate procedures in the classroom. Under circumstances when the prevalent agendas are incompatible, it is possible to point out non-negotiable agendas of school science. The results show that the use of specific procedures and precise
methods are communicated as normative and non-negotiable features. Students’ re-actualized experiences can challenge these agendas, for example, as students put a stated procedure in question.

The non-negotiable procedures which are described in this work relate to school science rather than to science. Similarly, the communicated precision relates to conditions of school science rather than of science. I argue that the ‘nature of science’ (NOS) is an insufficient concept when dealing with educational practices such as school science. Science involve neither educational purposes, nor children’s learning and therefore I suggest that the concept ‘nature of school science’ (NOSS) is used to point out particular features of school science practices. For example, features of a science language game, as well as features of an everyday language game make up the school science language game. That is, a school science language game involves transitions between science ways of meaning making as well as everyday ways of meaning making. The discrimination of the NOSS from the NOS implies that the legitimacy of school science can be based on educational purposes and that scientific practices can be seen as analogous to school science, without claiming that school science is a hybrid practice. That is, school science can be acknowledged as an authentic practice with educational purposes, illustrated in the four activities of Article 1.
Students’ participation in the realization of school science activities
Mattias Lundin
8 DISCUSSION

The last section of Chapter 7 concludes the discrimination of the nature of school science (NOSS). Accordingly the concept is central in this last part of the thesis. Chapter 8 consists of two major parts. First, I comment on the analytical approach and the theoretical perspective indicating the difficulty to discriminate language games. Second, a discussion of findings is presented.

8.1 Comments on the analytical approach

One purpose with the choice of theoretical perspective was to explore its applicability for research. At this point I argue that the theoretical ideas made it possible to elicit praxis without bringing about expectations rational from other points of views than those of the participants. However, to discriminate different language games in school is a complicated project. That is, to focus and classify a specific utterance, as part of a specific language game, constitutes a difficult task. The smaller the item for analysis, the more difficult to classify. In this thesis, such discrimination has elucidated the substantial conversational work, made as the students enter the school science arena and begin to talk about natural phenomena in a way that might be new to them. It is of course possible to argue that every conversation is completely unique but such a starting point implies a denial of language games. However, in a series of utterances (cf. Kevin’s conversation with his friends in Article 3), a broken continuity in meaning making can sometimes be interpreted. Then, one language game stands out in contrast to another. For example, students’ questions, grasping everyday points for references have shown shifts of language games (transitions). In the background of this thesis I explained the concept of family resemblances (cf. Wittgenstein, 1953, § 67). Such resemblances between utterances in a conversation is what I argued makes up the language game. However, one thing that has been focused in this thesis is transitions between language games. The identification of a transition is not based on resemblances between utterances but on a broken continuity, that is, a lack of resemblance between utterances. Yet, the discrimination of language games and transitions between them is difficult to analyze. In one of the excerpts the teacher asks if the students had heard the word ‘serum’ before. A student replied “A truth serum”. Then, the teacher answered “A truth serum (.) mm the question is if it exists?” By means of the utterance the teacher drew a dividing line and placed “truth serum” on the outside of the ongoing language game. Consequently, the exemplified conversation shows how a dividing line is drawn as the participants act according to their purposes of the ongoing project. Of course, truth sera can be part of a science language game but in this case the findings indicate they are not. That is, the teacher pointed out that “truth serum” was beyond the scope of their language game. The discrimination of
language games was based on their conversational activity instead of any pre-made assumptions concerning what content could belong to one or another language game. This does not mean that the participant consciously experienced a boundary. Rather, I suggest that the teacher (in the exemplified conversation) might have experienced an utterance that did not fully fit with the purposes (expectations). That is, boundaries do not exist in a general sense. Studying language games implies claiming “the speaking of language is part of an activity, or a form of life” (Wittgenstein, 1953, § 23). Language games are not something fixed. Symbols, words and sentences change as well as language games – some come into existence and other are forgotten.

Before turning to the discussion of findings I will discuss the school science language game in terms of continuity and change (transformation) (cf. section 4.4 where these concepts were given). This thesis has identified features which seem to preserve school science, that is, features of its realization that creates continuity. Examples are given as I present the ‘conclusion of a common platform’ (4th activity in Article 1). However, the findings have also shown how a school science language game can change. New aspects and approaches were invited to be shared although not necessarily effectuated. For example, the findings illustrate how the teacher asked for students’ opinions/ideas and how some of those were orchestrated with agendas of higher priority (cf. Chapter 2 on orchestration of agendas). The findings consist of features that imply an emergent structure. Consequently, the findings corroborate Wenger’s (1998) claim that practices are not stable but change. In addition to that, the findings show how a school science language game may change when new mediating tools are brought about. Wertsch (1995) illustrates how practices change when new mediating resources are used. In these findings new professional laboratory tools (for doing blood tests) did not change school science laboratory work. Consequently, a new mediating tool in a professional laboratory practice does not necessarily imply a change in school science methods. However, a new mediating tool can instead change how the methods used in school are justified. For example, the school science method can be justified as a way of elucidating central scientific concepts for learning purposes rather than an activity analogous to the laboratory practice. I now end the discussion of methodological and theoretical experiences and focus is accordingly turned to the discussion of findings.

8.2 Discussion of findings

Three themes will be presented in the following order. I begin by discussing agendas of school science and proceed with transitions between language games. These agendas as well as the mentioned transitions are then used to elicit the NOSS. Consequently, the third theme of the discussion of findings
Students’ participation in the realization of school science activities
Mattias Lundin

concerns the NOSS and serves to discriminate the NOSS from the nature of science (NOS).

**Agendas of school science**

This thesis set out to examine how different agendas are orchestrated in school science. That is, how students’ experiences and questions on one hand, and an already established science content on the other, can be part of the realization of school science. The findings illustrate how accounts of students’ experiences (re-actualized experiences) were part of the realization of school science. The first two activities, described in Article 1 illustrate classroom work that was organized to deal with students’ previous experiences. Every re-actualized experience need not have educative value in a way that they are fruitful to pursue (cf. Halldén, 1982). However, if a student is guided by his or her teacher, so-called non-educative interests or questions may well be used as a means of pointing out what is part of, or beyond the subject. On such occasions companion meanings (cf. Östman & Roberts, 1994) of school science are highlighted. The concept of companion meaning is central because it elucidates normative parts of meaning making such as what counts as a topic in a language game. The impact of companion meaning can be interpreted in the situation where students’ re-actualized experiences got very little attention in favour of safety issues. In this thesis several currents in how companion meanings were made, are described. Emphasis on students’ previous experiences, as well as non-negotiable precision and procedures are examples of such currents. Roberts (1998) describes different curriculum emphases that show currents in the companion meanings of *curricula*. Similarly, I have described teachers’ (and students’) agendas that show which currents are emphasized in the realization of school science. It is appropriate to study different agendas in the realization of school science, rather than curriculum emphases because the word ‘agenda’ indicates that something is intended to be accomplished over time.

Besides re-actualized experiences, the purpose of this thesis involves a focus on questions. The findings indicate that students’ questions have educative value. Questions that address students’ interests can, for example, be used to point out what is relevant. However, I do not argue that every account of a student’s interest has educative value. Yet, the possible conversations that can be associated with students’ interests in the field have educative value as they can, for example, show to students what is part of, or beyond the scope of the subject. These findings are contradictory to Gisselberg (1991) who argues that normal teaching is unsuited to being built on students’ questions. Furthermore, I argue that accounts of students’ interests are indeed possible to communicate with questions as well as accounts of previous experiences. I also argue that these become part of the learning activity. For example, students’ tentative use
Students’ participation in the realization of school science activities
Mattias Lundin

of scientific words, such as ‘hypothesis’ can be seen as an illustration of how they become “cultivated” into a particular use of a word. Another example that refers to cultivation is given by Sugrue (1997) who refers to teachers’ cultivation of students’ interests. In both applications the metaphor deals with nurturing. Sugrue argues that the growth metaphor for learning implies a peripheral role for the teacher and that it allows learners to pursue their interests. Sugrue claims that the metaphor does not indicate what these interests are that have educative value. However, the findings of this thesis illustrate that the teacher plays a crucial role for indicating what interests are relevant to pursue.

Two agendas of school science have been identified this far: features involving students’ experiences as well as students’ questions. However, these agendas are orchestrated with a science content. For example, the results show how students’ re-actualized experiences were orchestrated with the science content to make students participate. Driver (1983) describes a tension between two aims: the acquisition of knowledge and the use of students’ own inquiries in the pursuit of further knowledge. This thesis illustrates how an orchestration of agendas can be made by teachers, in that they address the tension that Driver describes. In this thesis such an orchestration is described by means of four activities (cf. Article 1) that involve, for example, teachers’ approval and rejection of different experiences that students relate. Regarding the orchestration, the results point out precision and procedures as emphasized and non-negotiable features of school science. What I have discussed so far, are different agendas that are part of school science activities and the orchestration of agendas. I now intend to discuss transitions between language games.

Transitions between language games
The translations that Szybek (2002) presents correspond to the transitions between different ways of meaning making that are described here. I argue that a transition from an everyday language game to a science language game correlates with Szybek’s first translation. The findings presented here indicate that transitions in this direction could be troublesome because the transition is directed towards the language game that the students are about to master. Consequently, these results point out difficulties when going from an everyday language game to a science language game. This particular kind of transition is not likely to occur as a quick change of words. For example, although Mark gave an appropriate explanation to the separation of urine, his explanations did not count as an answer to Kevin’s question. My interpretation is that as the two boys’ talk was based on different ways of meaning making, a thorough elucidation was needed in order to sort out the issue.
Szybek emphasizes the second translation (that is, from the science stage to the everyday stage of events) as crucial for making science relevant to students. In these findings, questions in a science language game evoked answers that concerned everyday items, described in a science language game. The findings have given examples of such transitions and indicated how students ask for everyday items that relate to the scientific concepts. That is, students engaged in relating scientific concepts to everyday items. However, these results do not implicate a determinate relation between question and transition. In the headline of the third article the word tool is chosen in order not to claim any determinant relation. Instead, a tool can be used for many different purposes. A screwdriver can, for example, be used for screwing or to widen a loose joint, furthermore a screwdriver can be used as a blackboard pointer in the classroom. Similarly, questions could be used for various purposes and different uses of a question may have different consequences.

The findings indicate that transitions are likely to take time and effort. My experience from this analysis is that a shift from an everyday language game to a science language game occurs slowly in a learning practice, such as school science. A word can be used in various language games and refer to different phenomena (cf. ‘organic’ in a science language game, referring to a domain of chemistry, and ‘organic’ in an everyday language game, referring, for example, to a non-toxic way of growing vegetables). Different ways to make meaning of words can be mixed in school science and a transition is likely to be tentative and gradual (cf. Sutton, 1996 as well as the tentative use of the word ‘hypothesis’, described here). Therefore, I regard direct translations between stages of events as a special case that I refer to a transition going towards a familiar everyday language game. In any case, a study of differences in meaning making is interesting in itself. If such a study elucidates separate ways of making meaning of one word, its results can provide supportive information that facilitates students’ discrimination of different ways of meaning making.

The transitions between the different ways of meaning making that I now have identified, in spite of difficulties, are salient features of school science that cannot easily fit into the NOS. That is, relating phenomena that have been experienced in contexts outside school science to the science activity, cannot be regarded as part of the NOS. Therefore, I argue that a concept that comprises the salient features of school science activities is needed. The NOSS is the concept that fills such a gap and in the following paragraphs I will develop the concept. I intend to start with discriminating the NOS and the NOSS while referring to activity.
The nature of school science (NOSS)

According to Bencze (2001), students rarely have opportunities to do science in school science. If we consider school science as a practice that should reflect the NOS, the issues that Bencze indicates are highly problematic. However, if we expect school science to be a practice that reflects the NOSS, we could conclude that the students observed by Bencze might have opportunities to perform school science laboratory work, in which crucial features of natural phenomena are illuminated to facilitate learning. Furthermore, school science laboratory work may provide analogies with professional science practices of various kinds. There is more to be said about my distinction between the NOS and the NOSS and in the following paragraphs I discuss the distinction in relation to previously presented research.

Just “doing science” is insufficient for developing understanding of the NOS (Schwartz et al., 2004). They argue that we cannot expect students to understand the NOS only by participating in a school science activity. I argue that students need support in order to make activities intelligible, for example, by pointing out reasons for the shape of school science activities. The findings illustrate that school science activities are not intelligible as part of a professional science practice but as a part of a student’s learning practice. I will now use the occasion when a new mediating tool for doing blood tests was mentioned in the school science setting (cf. Article 2), to exemplify. That occasion indicates that the school science practice relates to the NOSS and not to the NOS, because the activity was not transformed in a way that matched the new mediating tool. Consequently, school science provides an outside perspective for studying the NOS. School science also provides opportunities for teachers to relate their activity, NOSS features included, to various professional science activities, in which the NOS can be identified. For example, school science ways of performing blood tests are not equal to those of professional practices. That is, making features of school science intelligible, implies a discrimination of the NOSS from the NOS. I claim that students cannot be expected to learn the NOS as a companion meaning only as they just “do science”. Students participate in a learning practice in which features of the NOSS can be found. Teachers need to help students to reflect on the differences of practices to be able to discriminate the NOS.

Classroom management, routine chores and lack of resources are factors influencing teacher priorities (Khisfe & Abd-El-Khalick, 2002). In the findings presented here, the non-negotiable procedures illustrate how companion meaning is made in the setting. The results imply that communicating the reasons for the emphasized precision and procedure to students is important to
Students’ participation in the realization of school science activities
Mattias Lundin

the intelligibility of school science activities. Compare Article 2 where Mark’s questioning of the relevance of the chosen procedure is described. Furthermore, the emphasis on precision and procedure, communicated in the illuminated activities, can be related to Munby et al (2000). On basis of their interview study, they illustrate a similar emphasis as identified in this thesis. However, I do not agree with their characterization of school science as an inauthentic practice, because the different activities are clearly related to students’ science learning (cf. the four activities illuminated in Article 1). As a learning practice, school science cannot be regarded but as authentic.

However, the question is what impact this position has on how to regard transitions between language games. The findings have shown transitions between everyday language games and science language games. A crucial feature of school science is indeed the transitions between everyday ways of meaning making and the school science ways of meaning making that relate to science practices. I regard these transitions as a prerequisite for science learning. The concept of NOSS indicates that school science activities comprise features that are distinguishing for a learning practice. Carlgren (1999) claims that cultures outside school are not appropriate models for activities in school. On the other hand, Brown, Collins and Duguid (1989) describe school as a hybrid culture, being framed by one culture and attributed to another. My position is, in accordance with Carlgren (1999), that school science is not an apprenticeship system but an authentic learning practice. Nevertheless, the results have indicated that features of other practices (language games) are incorporated in the school science language game. In the next paragraph I suggest a way out of this dilemma.

A relevant question is how to address school science features that relate to other language games when claiming that school science is an authentic learning practice. One possibility is to abandon the idea of authenticity and regard school science as a hybrid culture (cf. Brown, Collins & Duguid, 1989). However, an alternative that is suggested by the findings presented in this thesis is to say that school science involves analogies with other language games. For example, analogous features of everyday language games as well as analogous features of science language games are possible to identify in school science. Previously, I presented the idea that school science is built of features of everyday language games as well as science language games. Provided that these features of out-of-school language games are not regarded as either inferior or superior, they can be called sub-language games of school science. Consequently, the authenticity of school science can be described in terms of the (sub-) language games used and the transitions between them. Talking about a particular school science language game fits with the concept of NOSS, because the NOSS is used to elucidate characteristic features of
school science that are separate from the NOS. The NOSS can be related to Hogan’s (2000) description of proximal knowledge about the NOS. Indeed, students’ knowledge about the NOSS is of proximal kind. However, I have not approached the NOSS from a metacognitive stance but studied it as realized in school science praxis.

The NOSS and the NOS also provide similarities. For example, the findings indicate students’ tentative use of words when learning a new subject. This tentativeness I associate with learning about what others have said about nature, that is, the tentativeness is part of the NOSS. However, Sutton (1996) describes how new scientific ideas are presented tentatively, for example, as claims. This latter tentativeness needs to be related to the NOS. Consequently, the tentative use of words can either be part of the NOSS or the NOS. The difference concerns what is the object of tentativeness: regarding the NOSS the tentativeness refers to learning what others’ have said about nature and regarding the NOS the tentativeness refers to learning about nature that is associated with research.

The discrimination of the NOSS from the NOS implies making the school science activity intelligible in different ways. Precision in school science activities is, for example, intelligible as a part of students’ safety (safety agenda), using a NOSS-perspective, whereas a NOS-perspective may elucidate accuracy in measurement as its rationale. This thesis has elucidated the concept of NOSS but yet only shown examples of what the NOSS is and I suggest further research to elicit how the NOSS can be discriminated from the NOS.

I argue that the findings illustrate both situational and contextual aspects of school science (cf. Hardwick, 1971). However, the crucial point does not concern what should be considered situational or contextual but different ways to outline the NOSS in praxis. The concept of NOSS that I have suggested here, differs in character from, for example, the messages of school science, described by Rowell (1996). The messages that she relates are indeed part of school science. However, written information is not subject to situational influences as, for example, students’ re-actualized experiences. That is, if we consider a particular genre, as Rowell, a written text has better prospects for keeping to the genre, than spoken language in an ongoing conversation, surrounded by various agendas. The illustration of the NOS in classroom praxis, presented here, complements the image of science portrayed in texts (as suggested by for example Rowell). Furthermore, my study of classroom work without intervention in teachers’ planning, complement Bartholomew’s et al (2004) fieldwork report because their findings are based on an intervention study.
Before ending this part of the discussion I state four themes of the results that the thesis has elucidated. Findings have shown:

- activities in the accomplishment of a school project. These deal with human biology and relate to school science as a learning practice.
- how the NOS is communicated as a by-product of instruction.
- different uses of questions for bridging language games.
- different roles students’ re-actualized experiences have in a school science activity.

These four themes constitute features that are distinguishing in the findings and they support the discrimination of the NOSS.

**Crucial school science talk**

I will now conclude three central themes of this thesis. First, communication about science phenomena is a complex project, especially when the participants are about to learn how to make meaning in the language game. The findings presented in this thesis show that the teacher played an important role for facilitating communication. Second, the findings also indicate that learning processes, based on students’ project work, were organized in a way where their questions and previous experiences were orchestrated with the established subject content. Third, the thesis shows how school science activities functioned to elucidate scientific ways of communicating and acting from other such ways in that transitions occurred, and in that the NOS was communicated as a by-product of instruction. An important part of these findings is the NOSS. The NOSS acknowledges features of school science activities, in contrast to, for example, science research activities. That is, from a NOSS perspective, procedures and precision can be understood as a teacher’s effort to ensure laboratory safety to students. If recognizing features of school science as part of the NOSS, school science activities can stand out as more intelligible.

In the introduction I mentioned my experiences as a teacher student, performing my first science lesson. On the basis of the results presented here, I argue that the idea to build on the students’ previous experiences might have been possible if I had started on a reasonable level. If so, there would have been an opportunity to create a communicative practice in which students’ experiences could be elaborated in relation to the science topic. My intention with this thesis has been to elicit features of school science activities to show what school science is like. The findings have pointed out conditions that I experienced as a teacher but that I yet did not then notice. For example, I knew about the idea to evoke students’ previous experiences in order to try to make students active learners although I did not fully utilize its possibilities. The results have pointed out that the talk subsequent to a re-actualized experience is
Students’ participation in the realization of school science activities
Mattias Lundin

crucial for including the re-actualized experience into school science and its ways of meaning making.
9 REFERENCES


Students’ participation in the realization of school science activities
Mattias Lundin


