Planning science instruction: From insight to learning to pedagogical practices

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Contents

Foreword ........................................................................................................................................................ 7
Introduction ................................................................................................................................................ 9
Abstracts: Key note lectures..................................................................................................................... 13
Full papers: Planning science instruction ...................................................................................... 15 - 69
Synopses: Reflecting on the science curriculum ........................................................................ 71 - 100
Synopses: The goal of scientific and technological literacy .............................................. 101 - 125
Synopses: Understanding scientific concepts ........................................................................ 127 - 152
Synopses: Pedagogical practices ................................................................................................. 153 - 188
Synopses: Resources for learning science in schools ......................................................... 189 - 223
Synopses: Resources for learning science outside schools ....................................... 225 - 244
Synopses: Learning to teach science ......................................................................................... 245 - 273
Authors of accepted proposals ................................................................................................. 275 - 278
Foreword

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

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

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

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

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

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

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

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

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

Introduction
Allyson Macdonald

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

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

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

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

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

The presentations at the symposium were organised into sessions which accommodated three to four papers on a similar topic and a smallish audience. Here we have used the opportunity to group papers together differently in the hope that the presentations are related to the themes of planning instruction, to decision-making, both large and small, and to insight, learning and pedagogical practices. It is our hope that this regrouping into seven major themes will bring surprises and insights into the complex world of teaching and learning science.

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

**The goal of scientific and technological literacy**

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

**Understanding scientific concepts**

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

**Pedagogical practices**

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

**Resources for learning science in schools**

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

**Resources for learning science outside schools**

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

**Learning to teach science**

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

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

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

**References**
Abstracts of key note lectures

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

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

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

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

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

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

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

In this talk I report on drawings of the natural environment produced by a sample of 13-14 year-olds in work undertaken with Carolyn Boulter and Sue Dale Tunnicliffe at the Institute of Education, University of London and funded by the ESRC. One of our interests is in the extent to which these young people see the world in the way rewarded in science lessons. With rare exceptions, school science generally assumes that for any scientific issue there is a single valid scientific conception so that alternative conceptions are misconceptions. However, the drawings reveal a plurality of ways in which the natural environment is portrayed and we conclude that there is scientific as well as other worth in this diversity.

We argue that schools need to take account of this diversity; many pupils will not be interested in a single, monolithic depiction of the natural world in their school science lessons.