SCIENCE EDUCATION – AN INTERDISCIPLINARY FIELD

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INTRODUCTION

I was a rather typical Norwegian boy in the 1950's and early 60'. Norway was busy rebuilding after WW2, and our heroes were the scientists and engineers – in addition to the national heroes in skiing and skating, of course. At a young age, I decided to become a physicist as well as a world champion in speed skating. Now, very much later, I realize that things did not develop as planned. They seldom do.

I became a relatively decent speed skater and spent 5 years of my life literally going in circles around a 400 m ice track. My career in science lasted somewhat longer. I got my university education as a physicist, but soon changed my trajectory. Some decades later I find myself as a professor in science education, a field that was nonexistent in my part of the world when I was young. Since I, more or less, was the first in this field in the Nordic countries, it might be that my story of converting from 'pure' science to science education has some elements that might be of interest also for others in the field.

FAREWELL TO PHYSICS?

In 1970, I received my university degree in experimental nuclear physics and got a scholarship to work towards a PhD in field. My future was supposed to be the measurement of half-lives of nuclear energy levels in Cobalt 57 studied by alphagamma reactions in a cyclotron. But I had started to get a growing unease about the project, and this was the source for a reorientation of plans.

As a student, I had been engaged in a rather critical and radical group where we worked to reform the emphasis in the contents of the university studies in science. We thought the focus was too narrow, merely a concentration on the well established concepts, laws and theories. We lacked an emphasis on the philosophical, ethical, human and cultural sides of science in our studies. A few of our professors had such interests, and they had nurtured our reading about such issues. For my own part, I read the philosophical as well political writings of Bertrand Russel, the debates between Bohr and Einstein, and also became involved in the debates (and actions) concerning nuclear power as well as nuclear armament. I became aware of organisation like Pugwash (now at http://www.pugwash.org/) and the Union of Concerned Scientists (now at http://www.ucsusa.org/)

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As a result, I felt more and more uneasy with the prospects of pursuing 'pure' science in a world where science was used and misused and not always to the betterment of people's lives. At the same time, my fascination with science and my love for science was still the same. I did not, however, see how to combine this 'love and hate' relationship with science. On the one hand, I still saw the history science as a brave story about radical thinkers' attempts to push back ignorance and superstition. In my eyes, the great scientists were rebels who fought against authority and tradition, be it secular or (more often) religious. On the other hand, my own work with gamma detectors in the lab seemed so far away from such ideals! I became, however, more and more concerned about teaching science, mainly about the philosophical, ethical and social aspects that I had missed in my own school and university studies.

Then something happened: The Physics Department at the University of Oslo decided to set up a new unit, a Laboratory for School Science. The background for this was that high school teachers missed a link back to the place where they had received their training. They asked for advice and in-service courses and they raised questions on matters concerning new developments in physics, about experiments, equipment, safety in the lab etc. The Physics Department offered me the job to build this new unit. After considering the offer for a day or so, I accepted. This ended my career in physics, and I started wandering into unknown territory. We had no proper name for the new field, and as far as I knew at that time, this was no academic field, but more a matter of practical action.

EMERGING NEED FOR THEORY AND REFLECTION

Our School Laboratory for Physics Education was established in 1971. Our activities were many and varied. We gave advice to teachers and schools on experiments and equipment (we even produced consumers' reports and compared competing kinds of lab equipment), we ran in-service courses on physics contents and safety in labs, and we developed a system where our Department of Physics could receive school classes to be introduced to current research activities etc.

Very soon, I was invited by our Ministry of Education to become member of official curriculum committees for various levels of the school system. It was apparent that few university scientists had shown such interests, and the few people who did, were warmly welcomed. There was no need to 'lobby' or fight your way into such positions. I became involved in making official, national curricula for many levels of our school system, including teacher training.

For me, this rapid rise to a kind of power (although invisible) raised some problems. My knowledge of physics was acceptable, but my knowledge of schools, teaching and learning was more than weak. I had, throughout my studies, worked as a part-time teacher, and my father was a science teacher who later became a school director and administrator, also on a national level. But I strongly felt the need for a stronger theoretical educational background in addition to my science background.
Consequently, I turned to the departments of Education at my university. But I soon came to realise that there were few or no one there who had any interests related to the actual teaching contents of schools, let alone to science and mathematics! Their own background, research, courses and teaching were on 'general' aspects of education: general psychology of teaching, learning and motivation, the schools as an organization, children with special needs etc. (Later, I have come to understand that this feature of Norwegian (and Danish) Educational departments is somewhat different from in most other countries.)

This strengthened my impression that science education was not an 'academic field', but simply an area of practical activity, where the actors could pick and choose from general theories of psychology etc. – if they felt the need for that sort of theorizing.

INSPIRATION FROM ABROAD

But I soon discovered that there was a 'world out there', in other countries, with people working more focussed and professionally in the area of science education. Some events became eye-openers for me: I happened to attend an annual meeting in the Association for Science Education (ASE) in Leeds. To my surprise, this association of science teachers had a long tradition, thousands of members, professional journals and strong links with academic groups doing research and development in addition to their activities like teacher training. This first trip to Leeds turned out to be the beginning of a long lasting connection.

This positive experience was followed by study trips to other countries and institutions. I went to Kiel, where they had just opened what is now known as IPN (Now Leibniz-institut für die Pedagogik der Naturwissenshaften). I became aware of a long German tradition in the field of science education and 'Fachdidaktik'. I benefited from my understanding of German, and was able to read their literature and take part in their discussions. This early experience with IPN has also been long-lasting, and I am now a member of the Scientific Committee (Sachverständigenrat) of IPN. This impressing institution has an academic staff of nearly 100 persons, and is probably the largest of its kind in Europe.

As one can understand, I gradually got to understand that science education was indeed an academic field that was professionalized and had a rather long international tradition, that there were academic journals, research institutes, associations, and an international 'invisible college' of active researchers. I did some reading on my own, but soon decided that I really needed a more thorough and systematic introduction into this (for me) new field.

A NEW START? RENEWED ACADEMIC STUDIES

A grant from my own university and a scholarship from the British Council gave me the possibility to study in Leeds, and I took an MA in education. This study introduced me to important areas like sociology of education, curriculum theory, educational psychology and to research methods in the social sciences. I worked in

My supervisor and main contact in Leeds was David Layton, who has ever since been an inspiration for my work. I remember in particular his historical account for the shaping of science curricula in Science for the people. The origins of Schools' Science Curriculum in England (Layton, 1973) Inspired by this, I wrote a small thesis on the development of the physics curriculum in Norway as part of the MA. When I was in Leeds, David developed the idea of the journal Studies in Science Education (SSE). Since then, the articles in this journal have been on the reading list for most courses in science education world-wide, I guess. It was, of course, a great honour when I, much later, was invited to be member of the Advisory Board of this journal.

The year in Leeds was a new start. I met many people who later became mentors as well as good friends. When I was in Leeds, Rosalind Driver returned from the US where she had taken her PhD under the guidance of Jack Easley. Somewhat later, they wrote a seminal article on 'Pupils and paradigms' (Driver and Easley, 1978).

In Leeds, I also met Edgar Jenkins, who also later became a mentor as well as good friend and research partner. Edgar followed David Layton as the editor of SSE, and also as editor of another influential publication, the UNESCO series Innovations in Science and Technology Education. I assume that these series publications have a world-wide influence that is not fully understood by science educators in the rich, industrialized world.

Although my own focus in the studies in Leeds were on science education, I had great and inspiring lecturers who really changed my thinking about a series of issues; like Michael Young, Basil Bernstein, Douglas Barnes and Lawrence Stenhouse.

Having returned from Leeds, I continued to develop the contact to science educators abroad, and in the late 70's I travelled to seminars, workshops and conferences that gradually made me grow into the field.

GRADUAL DEVELOPMENT IN NORWAY

My MA in Education from Leeds (1975) and the courses, conferences and seminars in the following years gave inspiration and perspectives for the development of academic studies in science education at my own university. In the years to follow, i.e. late 70's and early 80's, we also invited many of my new international friends and contacts to help us 'advertise' and develop the emerging field of science education. David Layton came several times, Rosalind Driver even more often.

Within the Faculty of Science we gradually developed studies to a cand.scient (Master) degree in the hitherto nonexistent field of science education. The themes for the dissertations in the period from an early start in the mid 70-s are symptomatic for the development of the underlying thinking as well as my own development and growth into the field. The first titles of the master thesis were strongly related to the subject matter in science: The analysis of textbooks, critical
scrutiny textbooks for possible misunderstandings in their presentations of e.g. scientific concepts, laws and theories. Somewhat later we were influenced by the works of Michael Shayer and Philip Aden on the conceptual demands of teaching science. This approach was strongly influenced by Piaget's stage theory. These perspectives are, somewhat later, summarised in Shayer and Adey (1981).

I also twice got HM King Olav's award for academic dissertations for work in this field: The first, in 1978, on the use of educational psychology in the teaching and learning of science. The second (with my colleague Svein Lie and others), in 1983, on gender and science education. All this was published as Norwegian books, except for some articles and chapters in books (see e.g. Sjøberg and Imsen, 1989).

MY PIAGETIAN STAGE…

As mentioned, I became influenced by the ways in which the theories of Jean Piaget were used in science education, and I started to do my own research on this foundation. In 1982, I finished my PhD on a thesis where I explored the relationship between the theories of Jean Piaget and physics as a discipline and a school subject.

The choice of Piaget seemed an obvious choice for a person with my background: Piaget had a science background (biological adaptation), he used a language with strong scientific connotations, he used mathematical logic to formulate his ideas about stages and he used more or less classical experiments from school science to elicit children's thinking (e.g. Inhelder and Piaget, 1958). It is also well known that Piaget admired physics as a discipline, he considered physics to be the prime example of a mature structure of scientific knowledge. All this made Piaget an obvious choice for me!

Through my work with the original texts of Piaget as well as translations and popularizations, I came to appreciate the philosophical and epistemological programme that was behind his life programme. It was a surprise to see how his texts were twisted and wrongly translated when they travelled from one language to another. It was (and still is) sad, but maybe not surprising, to see how his ideas often have been misunderstood and misused, often taken out of the epistemological context of Piaget's own thinking.

My own interest turned away from the stage theory of Piaget, and became more oriented towards the constructivist aspects of his theory. These can be found though the nearly 60 year's of active writings produced by Jean Piaget. There is good reason to revisit 'the early Piaget' from the early 1930's, where he wrote in detail about children's ideas of many aspects of the natural world. Many of these ideas were re-discovered when mainstream science education started to become interested in children's 'misconceptions', 'alternative paradigms' etc around 1980. A key actor in this development was Rosalind Driver, long before it became 'mainstream' and the dominating paradigm.
GENDER AND SCIENCE EDUCATION

In the Nordic countries (Sweden, Denmark, Norway, Iceland and Finland), the feminist movements (in plural!) have been strong for many decades, and any person with an interest in politics and social issues have been influenced by this. The feminists (of various kinds) were particularly active in the student organizations where I 'grew up' intellectually.

According to all international statistics, the Nordic countries are on the top on most indicators on gender equity. The UNDP (United Nations' Development Programme) publishes the influential Human Development Report every year (e. g. UNDP, 2005). This report contains many indicators for all countries in the world, and it has also developed a Gender Empowerment Measure. This is a combined measure for many aspects of gender equity; like level of education, participation and salaries in the labour market, positions held in politics and the economy, etc. The five Nordic countries are on the top of this list. But there is a Nordic paradox: In spite of the overall high level of gender equity, the choices of school subjects, studies and careers are more gendered in the Nordic countries than in most other countries.

One of the first issues we tried to address was to understand (in order to remedy) this situation. We soon came to realize that the reason for girls opting away from the 'hard' sciences (like mathematics, physics, and technology) had to do with the image and the more or less implicit values and (lack of) perspectives of school science. It seemed that girls opted out of science based on the same sort of objections that I had against science curricula and science teaching, i.e. the lack of historical, social, cultural, philosophical and ethical perspectives.

Hence, working for a better science curriculum and more gender equity became two sides of he same coin in my 'project'. Already around 1980 we started a project on girls and Physics, and with my colleague Svein Lie, we took active part in the establishment of the association GASAT, (Gender and Science and Technology) http://www.gasat-international.org/. The first conference was held in 1981, and we arranged the second in 1983. As mentioned, out work in the field was awarded HM King Olav's gold medal for scientific dissertations that year. The gender perspective has been strong in the various initiatives and projects that I have worked on throughout my career, like SAS and ROSE (see below.)

LARGE-SCALE COMPARATIVE STUDIES: SISS, TIMSS AND PISA

In the period 1982-86 I was involved in SISS (The Second International Science Study) as the national research coordinator for Norway. SISS was actually the first of such large-scale studies that Norway took part in. The political and ideological struggles around participation and interpretation of such projects is very interesting, but will take me outside the scope of this short chapter. In any case, I spent some years with SISS, also learning to respect the statistical techniques and the complicated logistics behind such large studies.
Although I became rather sceptical towards some of the educational interpretations and political misuses of such studies, I became convinced that Norway could benefit in many ways in the participation. Although I decided not to work any more with such studies myself, I lobbied and argued for Norwegian participation in the follow-up study, TIMSS (Third International mathematics and Science Study), as well as the later PISA-study (Programme for International Student Assessment) organized by the OECD.

Norway now takes active part in these studies, and my colleagues at Oslo University are responsible for the running of the projects in Norway. They are also key persons in item development etc. for the projects, in particular my good friend Svein Lie. At times, we have some internal difficulties in our group because I am taking part in public debates over what I consider to be rather detrimental educational consequences of these studies. My main critical points are of political and ideological nature: Results from these studies are often trivialized to become one-dimensional league tables, they create simplistic images of the overall quality of the school system, and they constitute a pressure to harmonize and universalize science curricula and testing. Such pressures run contrary to the need to contextualize curricula and to build on the culture, needs and interests of the learners.

FORMAL ESTABLISHMENT AND CONFLICT

By 1985, our work had started to be well established and we had Master students in not only physics education, but also in chemistry and biology, where they had also established School laboratories similar to ours in physics. Our Faculty decided to lift our activities away from just being a matter for each department, and they formed a Centre for Science Education at Oslo University. I got the job to lead this new development. At that time, Doris Jorde moved to Norway. (Doris, too, has a chapter in this book) She had a PhD in science education from the US, and came at the right moment. In the years to follow, we have been working closely together in building science education as an academic field. In fact, we complement each other quite well, both in contents and research methods: Doris has a biology background, while mine is mainly in physics. She is an expert on classroom interactions, studied with qualitative methods. My interests are more on the social, cultural, ethical and political aspects of science education, and as a researcher, I am better qualified in quantitative methods.

Our studies in science education were now accepted to be a regular part of the study programme at the Faculty of Education, and we had a broad portfolio of activities. Then an administrative decision changed the plans. The University decided to reorganize several of its activities, and formed a new Department for teacher education. In this process, they moved our Centre for science education to this unit, which later became a department under a new Faculty of Education. We strongly opposed this decision, but in vain. From then, we suddenly found ourselves employed at another Faculty. The situation was rather strange, because our students and the degrees that we awarded still belonged to the Faculty of Science and Mathematics.
This experience can exemplify the problematic nature of the academic field of science education. It is in part natural science, in part social science. And it can often be seen as part of teacher training. This challenge of having multiple identities and loyalties is something we have to live with in our field, and I am aware that different organisational solutions exist in different countries, even with different setups in each country.

For me, this rearrangement was a hard time. I had been urged by my faculty to build a new unit and a new activity that the Faculty needed and wanted. When the job was done, we were moved to another faculty, away from our science home and background. The price for working interdisciplinary seemed to be a loss of identity. For some time, we fought against this decision, but I became so frustrated with fighting bureaucracy that I finally grasped an offer to leave the University for another job. That proved to very rewarding.

INTERNATIONAL INVOLVEMENT THROUGH UNESCO AND NORAD

I have worked most of my academic life from a base at University, but the exception is the period 1990-1993, when I worked as educational advisor for the national commission of UNESCO and for Norad (The Norwegian Agency for Development Cooperation). My task was to analyse and give advice on educational initiatives by e.g. UNESCO and on policy issues and projects relating to Norwegian aid to the education sector. These years were extremely interesting, and gave new perspectives as well as many new contacts all over the world. Among other things, I learned to see the economical and financial aspects of educational systems, and their role in national and human development.

In 1993, I returned to Oslo University, now as professor in science education, actually the first of its kind in Scandinavia, and now at the Faculty of Education. I brought with me many of the ideas from my new international orientation. Many of my later commitments and projects were spin-offs from this period, in particular activities oriented towards developing countries. I used some of the international meetings to build projects that later has developed into research cooperation.

TWO PROJECTS: SAS AND ROSE

One example of a project that grew out of my years with UNESCO and Norad is the project **SAS** (Science and Scientists) in the period 1994-2000. Together with Jayshree Mehta from India and Jane Mulemwa from Uganda, we developed this project, a survey among young learners (age 13) on various aspects relating to their views on science, scientists and school science. SAS was meant and designed to be a small, exploratory study, but many scholars from different countries wanted to join the study, and it grew beyond our expectations (and resources!). More that 20 countries joined the study, and we got and coded data from some 20 000 students. For many of our international partners, this was the first involvement in international research cooperation, and many of our colleagues wrote national reports and
articles. International results are published in Sjøberg 2000 and 2002b. There was a strong gender agenda behind the ideas of SAS, and most of the researchers were female researchers, also from developing countries.

The SAS study may be seen as pilot study for the much larger and better planned study, ROSE (The Relevance of Science Education). This project started in 2001 and is likely to continue for the years to come. It has funding from various sources, mainly from the Research Council of Norway. ROSE is an international comparative study that taps into the diversity of interests, experiences, priorities, hopes and attitudes that children in different countries bring to school (or have developed at school). The underlying hope is to stimulate an informed discussion on how one may make science education more relevant and meaningful for learners in ways that respect gender differences and cultural diversity. We also hope to shed light on how we can stimulate the students' interest in choosing S&T-related studies and careers. ROSE has, through deliberations that involved science educators from all continents, developed an instrument that tries to map out attitudinal or affective perspectives as seen by 15 year old learners. There are about 40 000 students from 35 countries taking part in ROSE. About 10 PhD students from different countries will base their thesis on ROSE data. A report on the project rationale, development and logistics is available (Schreiner and Sjøberg, 2004), (also from the web site: http://www.ils.uio.no/forskning/rose/ Results on various topics have been published (Schreiner and Sjøberg, 2005, 2006) and Camilla Schreiner (2006) has based her PhD on ROSE. (see section further down)

IOSTE AS INTELLECTUAL HOME

There are many international organizations and associations in the field of science education. I am member of many of these, and I have been rather active in some of them over the years. But I consider only one of these organizations as my intellectual home. I am thinking of IOSTE (International Organization for Science and technology Education). IOSTE developed during the cold war out of the need for international understanding and dialogue, and became a meeting place for S&T educators who shared some values and beliefs. They also shared a vision that S&T education should face the real challenges of our time, including sustainable development and the empowerment of people to take active part in all aspects of life in society. Science and technology as vehicles for betterment of life and for development of critical citizens in living democracies are key common concerns.

Key persons in IOSTE have been Peter Fensham, Glen Aikenhead, Jayshree Mehta, Jim Gaskell and many others. The biannual international symposia of IOSTE are important events in my life, and they are more truly international than many other conferences in S&T education. Participants come from all over the world, including developing countries, and the conferences are also hosted in places that indicate this profile. The last venues have been Enschede in the Netherlands, Edmonton in Canada, Durban in South Africa, Sao Paolo in Brazil and Lublin in Poland. In 2006 the venue is Penang, Malaysia.
I have been a board member of IOSTE for many periods, and I also served as IOSTE chair in the period of 2002-2004. Professional associations like NARST and ESERA are oriented only towards academic research, and they do not have any explicit value commitments except the promotion of high quality research. IOSTE has clear value commitments, and the symposia leave room not only for presentation of research, but also for discussions on matters of political, social and cultural importance relating to S&T in society and in education. There is certainly a place for both kinds of organizations, but I get more joy and personal inspiration out of IOSTE than of the others.

WIDENING THE RESEARCH PERSPECTIVE: RECENT PHD STUDENTS

For me, science education is a very wide and interdisciplinary field of research, development and action. It resists being captured by a strict and normative definition, either from the 'inside' of the field or (even worse) from people standing at the outside and wanting to impose restrictions on what counts as science education. Let me illustrate the great variety of the field with examples from my own research students and their PhDs. In the period 1996-2001 I had a grant from the Research Council of Norway on Science education for citizenship. (It may be of interest that the grant came from the Science division, and not from Social science in the Research Council). The project resulted in three PhDs and I also wrote a book with the project title, and this is now the standard textbook for science teacher education in the three Scandinavian countries, where the book is slightly adopted to national needs in cooperation with colleagues in Sweden and Denmark. (Sjøberg, 2004)

The three PhDs on the project are these

Erik Knain (1999) wrote his PhD (in Norwegian) on "The silent voice of science education". Some English articles are based on this thesis (Knain 1999, 2001). The thesis was a discourse analysis of science textbooks, where he used social semiotics linguistic analysis to reveal open and more hidden ideological and philosophical positions in the texts. The PhD was awarded an academic price for the most outstanding at the faculty that year. Through his PhD work, the former astrophysicist Erik had turned into an expert on linguistic analysis and social semiotics. He now lectures at university level, also in his new field!

Stein Dankert Kolstø (2001) wrote his PhD on Science Education for Citizenship. Thoughtful Decision-making about Science-Related Social Issues. This thesis is in English and is based on a series of articles, i.e. the common format in science, but still not so frequent in science education in most countries. The thesis is centred on how students (age 17) cope with socio-scientific issues close to their own environment. The actual example was the possible health hazards by living close to high voltage power lines. Stein studied how students strived to make up their own personal judgements on the various sides of this controversy. How the used (or did not use) their science background, how they weighed the science knowledge against values and emotions. A key issue was trust and argumentation.
Again we notice the rather dramatic reorientation. Stein Dankert was initially educated as an atomic physicist, and he is now an expert on text analyses, argumentation theory, socio-scientific issues, consensus conferences etc.

Marianne Ødegård (2001) presented her PhD thesis on *The Drama of Science Education. How public understanding of biotechnology and drama as a learning activity may enhance a critical and inclusive education.* Marianne has a background as a biologist, but is also educated in drama and role play. She is also an experienced science teacher. In her thesis work, she managed to combine these interests. Her chosen science theme was current controversies and ethical conflicts in biotechnology. She uses drama and role play both as teaching methods as ways to elicit the views and value judgements from the students on these issues.

The great diversity of approaches and perspectives are even more evident in the most recent PhDs written by students of mine:

**Astrid Sinnes** (2005) wrote her thesis on *Approaches to Gender Equity in Science Education. Two Initiatives in Sub-Saharan Africa Seen Through a Lens Derived From Feminist Critique of Science.* This topic was partly chosen because I had been involved in several initiatives in Africa to promote gender equity in science education, i.e. to improve material conditions, to remove barriers, to increase participation and achievement etc. These initiatives were financed by external donors, but organized and driven by African science educators, mostly women. As can be seen from the title, Astrid tried to interpret their positions and underlying ideologies with theories based on different positions of feminist theory. She analysed documents, interviewed a great number of the actors in the field etc. Again, Astrid has gone a long way, also in a very literal sense, from her background in biology.

**Camilla Schreiner** (2006) wrote her thesis based on the ROSE project (The Relevance of Science Education), described in a previous paragraph. The title of Camilla's thesis is *Exploring a ROSE-garden. Norwegian youth's orientations towards science – seen as signs of late modernities.* In the thesis Camilla uses theories based on contemporary sociology and youth research, in particular theories of late modernity. The empirical work is rather advanced statistical analysis on students' responses on the ROSE instrument. The focus is on the identification of particular student types in Norway, but she uses the international data to contrast and to validate her findings and interpretations. Camilla had a background as a data engineer, later as a geophysicist. Now she is an expert on sociology, youth research and on survey methods.

As can be seen, the diversity of research problems, theoretical positions and research methods is great. If there is a common denominator, they do address problems that are felt to be important, be it socially, politically or educationally. (At least by the researcher and supervisor!)

**Mentors and Inspiration**

I have already mentioned the inspiration I got in my Leeds period from getting to know people like David Layton, Rosalind Driver and Edgar Jenkins. Somewhat
later I met Peter Fensham for the first time. I liked and admired the way his ideas about science education always were underpinned by a set of human values. I know that I was just one of many young people who have benefited from his generosity and personal warmth. We met first time at a UN conference on Science and Technology and the Future Human Needs in India. After working together there on issues of Social responsibility of science, he invited me to spend a sabbatical at Monash in 1989. I actually stayed with my family in a small flat in his house. I am aware that many other colleagues have been treated with the same generosity. In Peter's writings, but even more so in conversation, I found ideas that I could easily embrace, be it on the significance of science for all, on the concern for the environment and many other aspects with a social and ethical underpinning. The cooperation with Peter also developed into a personal friendship, and we have spent time together also in the mountains in Norway.

Of special significance for my own development was also John Ziman. Although his main interest was not in science education per se, he made important contributions to the basic thinking in this field, too. I had the pleasure to get to know John through various committees as well as on meetings. After an impressive career in physics, John spent the last decades of his life to issues on the interplay between science and society (see e.g. Ziman, 1984).

Another important mentor has been Glen Aikenhead, and I have learned a lot through friendship and cooperation with Glen over the years. I am not sure that I share his views on the epistemological status of 'indigenous science', but I do share his value commitments to working with marginalized groups.

I have also had the pleasure to work closely with Joan Solomon, in particular on STS issues and as an international committee for the great Portuguese initiative Ciencia Viva. This national initiative is probably the most ambitious attempt in Europe to promote 'the culture of science' in a country which was indeed very little developed after the fall of the old, semi-fascist regime in 1975. The key person for doing this is Jose Mariano Gago. He is (or was?) professor of physics at CERN, and has now been Minister of Education and Science in Portugal for several periods. He is also pushing the same agenda in the EU. On his initiative, the EU made a thorough report on the situation for S&T in education in Europe. I was a member of his team, and John Ziman was our rapporteur. The report has the telling title "Europe needs more scientists!" (EU, 2004) and has proved to be very influential in shaping EU policies in this area.

**SCIENCE AND SOCIETY ACTION PLAN IN THE EU**

Although science in schools has been the major concern of most of my career, I have always had a somewhat wider interest relating to many aspects of science and technology in society. In recent years, I have got many possibilities to reorient myself in that direction. The European Union is putting a lot of effort into joint research and development. The current Frame Programme 6 (FP6) includes several initiatives under the umbrella of an Action Plan for Science and Society. When this was at a planning stage, I was invited to present a background paper for the Euro-
pean Ministers of education and research when they discussed ways forward in this domain. A revised version of this paper is published in Sjøberg, 2002a. I am happy to see that many of the ideas that I put forward are also visible in this plan.

Later, when the Action Plan was put in operation, I was invited to be a member of the Expert Advisory Committee for this initiative. The S&S initiative covers aspects like ethics, gender equity, public understanding and dialogue, science communication and science education. In addition to being a programme of its own, these aspects are also meant to cut across all the different thematic areas of research in the EU. The work in this group has been extremely rewarding, and has again given me new perspectives on issues that I consider to be of high importance.

It has also implied that I have been engaged in several important projects and initiatives of great political and educational significance. One of these is the Eurobarometer studies, large surveys of the entire EU population. In 2005 two of these studies addressed people's attitudes, interests, values and knowledge related to science and society. (Results from these and other Eurobarometer studies may be downloaded from http://europa.eu.int/comm/public_opinion/)

Many of the questions raised in the large-scale Eurobarometer surveys are identical to the questions that we raise in ROSE. The influence is two-ways. When we developed ROSE, we borrowed items from previous Eurobarometer studies, and later, I could argue for the inclusion of ROSE items in the 2005 Eurobarometer. We are now involved in very interdisciplinary research cooperation to utilize the rich data that we now have on values, interests and perception related to S&T among students as well as the adult population.

CONCLUSIONS AND REFLECTIONS

The writing of this brief autobiography has prompted me to think and reflect in ways that one seldom gets time to do. One has to take stock and try to find patterns in one's professional and personal life story. Some concrete outcomes of my career so far are easy to summarize. I gradually grew into a new field that did not exist in my part of the world. Now it is rather well established, in Oslo as well as in other places in Norway. A similar development has taken place in for instance Denmark and Sweden, and I have been involved in many of these processes. In Oslo, we have now 'produced' more than 100 candidates who have a Master degree in science education, and about 15 with a PhD. I have been involved in many of these activities, and also pushing for these issues in media and public debates. It is of course also rewarding that my book in science education (Sjøberg, 2004) is widely used as a basic textbook in all three Scandinavian countries.

I have received several recognitions of the value of my contributions. It was very moving that Nordic colleagues in science education researcher produced a joint book in honour of me on my 60'th birthday (Jorde and Bungum, 2003). This book is a kind of state-of-the-art of the field of science education in Norway, and contains research from 25 of my colleagues, mainly former students of mine. In 2005 I also received the award from International Union of Pure and applied Physics for my contribution to physics and science education. As can be evident from
In this chapter, I also have a long series of international commitments and engage-
mements, in fact only a few of these have been mentioned.

There has never been a career plan behind this development. I have sim-
ply followed my nose and my interests as they have shifted. This is a kind of lux-
ury one can afford when one enters a new field that has no clearly defined tradi-
tions, research paradigms, authorities and no defined theoretical 'canon'. This was
the case for the field of science education in my country some decades ago.

The process of my professional development may indeed seem very hap-
hazard. But when I try to see this in perspective, I realize that there is some conti-
uuity behind it. In fact, I have in the last years returned very much to the perspec-
tives that coloured my years as a student: the interest for science in a wider social
context, including social, ethical, cultural and indeed political dimensions.

The field of science education internationally is to a large degree domi-
nated by 'retrained scientists' like me. Our activities often reflect our own original
training, culture, world-views etc. The science education community is often apo-
litical and not very oriented towards culture, ethics and social concerns. This orienta-
tion is often also reflected in the choice of research problems as well research
methods. The dominating research has been (and still is?) an orientation towards
teaching and learning in a relatively narrow sense, the understanding of scientific
concepts, often based a standard design of pre-test, treatment, post-tests and statis-
tical testing of learning gains.

In the last decade or so there seems to be more variety and openness in the
research agenda. Science educators are discovering the social and political aspects
of science (pure and applied) as well as science education. People with a political
and social science background often get a feeling of *deja-vu*. We seem to witness a
rediscovery of the debates of the 1970s (at least in Europe) based on ideas from
Paulo Freire, the Frankfurter school and critical theory, the cultural and gendered
nature of knowledge, including science concerns about equity and discrimination,
education as reproduction of power structures and class. I do indeed welcome such
a shift of focus. Science education research is more than classroom studies of
teaching and learning.

The problem here is evident. The newly converted always have a tendency
taking new ideas to their extremes. The 'discovery' of recent cultural, feminist
and other critiques of science can easily be exaggerated. In the rejection of naïve
positivism, many jump to the other extreme, embracing all sorts of relativism and
subjectivism. Some also embrace 'indigenous science' in ways that seem to be
based more on wishful thinking than on epistemological analysis. Many consider
such positions to politically radical stances, while they may in fact be counterpro-
ductive and reactionary.

Being part of this world-wide community of educators, researchers and
activists has been (and still is, of course) exciting and rewarding. Science is not just
a school subject and an academic discipline. It is shaping our material world as
well as our world-views and ideas. Science and technology have a Janus-face, they
can be evil and good, they can save lives, but also take lives. They can liberate
minds and improve material conditions, but can also be used to cause destruction,
oppression and domination. As science educators, we have to face this wide array of challenges, and to find our own purpose and meaning. And we have to set our own agenda for research based on the concerns and priorities that we value. Of course, we do not always have the possibilities to freely make priorities in the way I suggest here, we are all constrained also by material resources and more or less political priorities outside our own range of influence. But the room for independent action is often larger that we think.

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